RAVENEL'S ROAD PRIMER

FOR SCHOOL CHILDREN

BY

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Compiled and prepared at the request of the National Chairman,
"Good Roads for Child Welfare Department,"
National Congress of Mothers

BEING

The elementary principles and practices of road-making, the causes and effects of good roads, their location, grades, drainage, maps and profiles, construction and maintenance, narrow and wide tires, and some kinds of roads and machinery necessary for the use of road-builders

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teract the allurements of city life, for the country boy and girl; socially, in drawing our farms and firesides nearer together, thus promoting friendly intercourse and culture; commercially, as a means of travel and traffic; and educationally, by bringing the school-houses and homes into closer proximity.

If our great educational institutions have seen it advantageous to the youth to teach the trades in the schools, why not the world-wide benefit of road building?

Mrs. Hale has well said:

> O wondrous power! How little understood,—
> Entrusted to the mother's mind alone,—
> To fashion genius, form the soul for good!

THE AUTHOR.

GEORGE WASHINGTON, HIGHWAY ENGINEER

AS an inspiration to our rising generations, and to dignify the profession of Highway Engineer, we call the attention of the American youth to the early exploits of the "Father of his Country" as a surveyor and highway engineer.

The illustration on the opposite page is a photograph of George Washington's Surveying Outfit, now in possession of the Department of Education of the State of New York.

Pasted in the inside cover of the instrument box is a pen-written statement as follows:

"The instruments contained in this box, together with a case of protracting instruments in a shagreen case, two surveyor's chains and the wooden pins used with the same, were the property of General Washington, and used by him when a very young man.

"These instruments descended to my father, Col. William Washington (the General's oldest nephew), and from him to me, and

by me presented to my son, Lewis W. Washington, February 10th, 1854."

(Signed) "G. C. WASHINGTON."

"GEORGETOWN, D. C., *Feb'y 10, 1854.*"

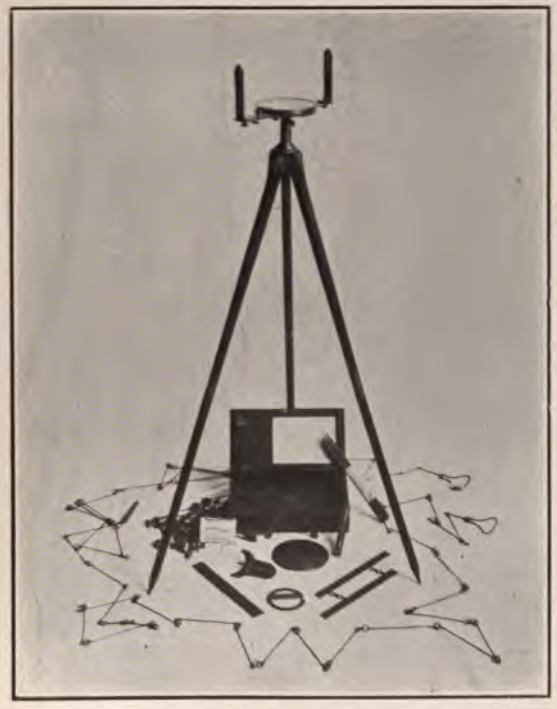
General Washington commenced the study of surveying when but fourteen years of age, and was appointed by Lord Fairfax surveyor for his own lands when just sixteen years old; after two years' service with Lord Fairfax he became public surveyor of the province.

This certificate of record is in the Culpeper Court House, in Virginia:

"The 20th of July, 1749 (O. S.), George Washington, Gent., produced a commission from the president and master of William and Mary's College, appointing him to be surveyor of this county; which was read, and thereupon he took the usual oaths."

He also wrote a "Book of Surveys," the manuscript of which is now in Cornell University. He is, in addition, accredited with being a valuable aid, as consulting engineer, in the plans of Major L'Enfant, who is given the credit for the details of surveying and engineering embodied in the general planning of our National Capital, Washington City, D. C.

Our first President was not only a surveyor, but was



GEORGE WASHINGTON'S SURVEYING OUTFIT

evidently a highway engineer of at least rare native ability, as he was the first to lay out, map, and recommend the route or course of the general highway known as the National Pike. He was also the prime mover in the building of the Chesapeake and Ohio Canal, which he afterwards stated had become "the channel of conveyance of the versatile and valuable trade of a rising empire."

It is to-day conceded that the channels of travel and traffic located by him are the best in alignment, the best graded, and the best macadamized roads in America.

Consider the work of the "Father of his Country" and let no mortal man be too proud to follow his example.

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CHAPTER I

WHAT IS A ROAD, AND WHAT ARE ITS EFFECTS?

A ROAD is the means of internal communication and transportation between points in any country; a place where one may ride or drive; it is an open way appropriated for public passage and travel, for wagons or other vehicles, and is necessary to the good of every community.

There are, however, other means of internal communication and traffic besides the ordinary country roads, such as tramways, railroads, canals, and navigable rivers. The first three are, like roads, the handiwork of man, while the last is a God-given resource, and is taken advantage of and improved by man's genius.

It has been said that roads are a certain test of the

degree of civilization in any country, and yet it is also said that the common roads of parts of the United States are inferior to those of any other civilized country in the world. The construction and improvement of a country's roads are strong evidences, therefore, that its people are emerging from the rude to the refined state.

In many countries the length of roads is not measured by miles, as in this country, but by the length of time it takes to travel over them; for instance, if it takes two hours to travel between two certain points, they do not say that the distance is ten or twelve miles, but that it is two hours.

So it may be said, therefore, that good roads, that is, permanently improved roads, really shorten the distance between points, when the time of communication is considered, instead of the number of miles they are apart.

In other words, it affects the community spiritually, because it moves the churches and the Sunday schools nearer to the homes, by shortening the time to go and come; it affects it morally, because it makes a country

community so much more desirable socially that it removes the craving of the rural youth for the deceptive, immoral enticements of the metropolitan city; it affects it socially, because it brings the firesides closer together and the social centres and gathering-places nearer to the homes; commercially, because the better the roads the easier and cheaper it is for the farmer to get his produce to the market and the consumer, and the greater his profit, and that of his employees.

For the same reason it helps a community educationally, by creating a closer proximity between the school-houses and the homes.

Suppose good roads in any community should eventually mean rock roads, over which school children could then walk to and from the school-houses, and never encounter mud even to the soles of their shoes; is not that helping education?

Another source of education that good roads make possible is the Rural Mail Service. The man in the city gets his daily paper and magazine delivered at his door, and so will the farmer enjoy this educational facility and comfort if good roads prevail, and the mail

carrier can reach him in an hour, instead of three. This all aids educational advancement.

QUESTIONS

1. What is a road?

Ans. A means of communication and travel between places.

2. Name some other means of traffic.

Ans. Tramways, railroads, canals, and navigable rivers.

3. Of what are roads in a country a test?

Ans. Its civilization and progress.

4. What does the improvement of its roads and highways denote?

Ans. That the condition of the people is becoming more refined and progressive.

5. How do good roads affect a community?

Ans. Spiritually, morally, socially, commercially, and educationally.

6. What is the time effect of good roads as to distances between places in any community?

Ans. Good roads shorten the time in going from one to another.

7. To what is that equivalent?

Ans. Shortening the distance as far as travel is concerned.

8. How do good roads affect a community spiritually?

Ans. They bring the churches and Sunday schools practically nearer to the homes.

9. How, morally?

Ans. They make the social life of a community more attractive, and thus keep the boys and girls at home, and away from the ensnaring attractions of big cities.

10. How, socially?

Ans. They bring the firesides closer together, and nearer to the places of public gatherings and amusements.

11. How, commercially?

Ans. By enabling the farmer to reach the market quicker with his farm products, thus saving time and expense.

12. How, educationally?

Ans. By making access to the school-houses quicker and easier.

CHAPTER II

ROADS — THEIR ORIGIN AND EXTENSION

THE most primitive type of road is a trail through the unexplored forests, made by travellers who blazed the trees as they went, to be able to return safely and certainly to the starting-point, probably their hut or camp.

The next step in road extension is the pathway, or bridle path, taking its name from the fact that it was used only for pedestrians or for riders but not wide enough for the use of wheeled vehicles.

Every community recognizes, not only the advantages of roads, but that roads soon become a necessity both for social communication and commercial purposes; so that the next step in road-building is the pathway widened for the use of wheeled vehicles for local purposes, such as hauling lumber for the primitive building necessities, wood for family uses, and the transporting of commodities for barter and trade among the pioneer settlers.

This type of road is what is known as a common

country road, or wagon road, and brings us up to the period of improved roads or highways. Common earth roads are classed as follows: A State road — one built on the main thoroughfare between the principal cities and towns of a State, and of a stipulated width, such roads being kept up by a road tax in some States; a county road, the width of which is fixed by order of the proper county authority, and amply wide for its purposes; and the common or neighborhood road, of less width and less commercial importance, usually existing by common consent of the land-owners in the community who use it.

All roads are more or less subject to State and county care and authority, and are repaired and kept open and passable by the expending on them of their proportion of the road tax of the county in which they are located.

The extension of roads, from the primitive to the most highly improved, continued as the necessity of the times demanded, until to-day we have bicycle paths, auto-cross-state highways and avenues, all highly improved and scientifically graded in compliance with the demands of the increase in population, development, and

prosperity. Our roads are the veins and arteries of our country; and as the blood of the body flows through our veins and arteries for life-giving purposes, so do our commercial and agricultural products flow as a matter of vital necessity through these avenues of traffic.

They supply the life-blood of the body-politic and provide the necessary gateway for our overflow of products, whether in the factory or the farm.

QUESTIONS

1. What is the most primitive road?

Ans. The trail blazed by the pioneer through the forest.

2. What is the next step noted in road extension?

Ans. The footpath or bridle path for man and horse.

3. What road followed the foot and bridle path?

Ans. The bridle path widened for wagon use.

4. How are roads classified?

Ans. State roads, county roads, and neighborhood roads.

5. What is a State road?

Ans. A road whose width is fixed by State authority and whose maintenance is by State tax.

6. What is a county road?

Ans. One of fixed width and under control of county authority.

7. What is a neighborhood road?

Ans. One whose width and maintenance are governed by common consent of the land-owners who use it.

8. How are roads kept open and passable?

Ans. By expending on them their proportionate share of the road tax of the county.

9. What creates the demand for good roads?

Ans. The country's increase in population, its growth in wealth, and its expansion in industry.

10. To what are roads likened?

Ans. To the veins and arteries of our bodies.

11. Why?

Ans. Because, as the blood flows through our veins and arteries for life-giving purposes, so the commercial and agricultural products of the country flow through these avenues of traffic.

12. What do they provide, commercially?

Ans. A gateway for the overflow of products of either factory or farm.

CHAPTER III

LOCATION

THE first and most important step in practical and scientific road-building is the location or laying out of the road.

By location is meant the marking on the ground of the line between such places as it is intended that the road should reach or pass through, keeping in mind constantly the requirements of a good road as to distance, nature of soil, and ascent and descent, or grade.

There is an old axiom, that a straight line is the shortest distance between any two points, so that, all other things being considered satisfactory, the most direct line is the most desirable.

In a level country the alignment is easy: it is simply running a line connecting the initial point and the objective points. But when great irregularities of surface interfere, it is as difficult as it is important; for the grade line — the rise and fall — must be kept in mind

all the time, and it takes an instrument or the eye of an experienced engineer to determine this.

Another important item of cost to be considered is the equalizing of the cuts through the hills, and the adjacent fills, or embankments, across the hollows.

When the earth taken out of a cut is just sufficient to make the embankment, it is moved only once, as it is hauled from the cut to the fill; but if the cut is less than the embankment, more earth has to be hauled to make that embankment; and if the cut is greater than the embankment, the surplus or extra earth must be hauled off.

So it is often the case, that a deviation from the straightest and shortest course is necessary to overcome or avoid such serious obstructions and barriers as hills, hollows, streams, swamps, or other undesirable conditions in road-building and maintenance. In other words, the road should be as straight as possible; but its shortness should be considered subordinate to the easiness of its grades, in going up over hills or down through deep hollows. Its cost also should be considered, unless money is no consideration. This is self-evident, for any one

knows that steep inclines and declines on a road are perpetual hindrances in hauling loads over it. This will be fully treated in the chapter on grades.

The illustration opposite shows that "the longest way round is the shortest way home," as to time. To go straight ahead, one of two things would have been necessary: the expensive cutting down of the abrupt hill over which the road would have necessarily passed, or a very steep grade over it.

The first may have been more than a country road district could afford; and the latter should always be avoided, as such a grade would be a perpetual hindrance to travel.

As regards the matter of cost, it would seem to a child that the cheapest road to build would be the shortest, but that is not necessarily so. In crossing high hills or deep hollows, either expensive cuts and embankments have to be made, or steep grades have to be used; when by skirting or going around a hill or hollow, only a short increase is made in distance, and both heavy costs and steep grades may be avoided.

There are three surveys usually made by the engineer

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whose duty it is to locate a road, though all of them may not be necessary in every case. They are the *reconnaissance,* the *preliminary survey,* and the *locating survey.*

The *reconnaissance* is usually made on foot or horseback, and is made for the study of the conditions of the country, its watercourses, hills, valleys, and soil formation, and to get the probable cost of construction, and the directions and locations of the country better fixed in the mind of the engineer before determining on the alignment of a road, railroad, or canal. For this purpose he usually takes no other instruments than the pocket compass, the tape, and field glass.

The *preliminary survey* is made with the help of the chain and such instruments as the compass or the transit and rod to determine and record the bearings and angles, and the level and level-rod to determine the comparative elevations of the hills and valleys.

The *locating survey* is also made with the same instruments and for the same purposes, only that any errors in the preliminary survey as to course or grades are corrected, and the location of the road is finally and per-

POCKET COMPASS

ENGINEER'S TAPE

FIELD GLASS

SURVEYOR'S CHAIN

ENGINEER'S 100-FOOT STEEL CHAIN

SURVEYOR'S COMPASS

ENGINEER'S TRANSIT

ENGINEER'S LEVEL

manently determined, after approximate estimates are made as to costs.

TRANSIT OR COMPASS ROD

LEVEL ROD

QUESTIONS

1. What is the first and most important step in building a road?

Ans. Its proper location or laying out.

2. What is meant by location?

Ans. The marking of the line of the road on the ground between such places as the road is intended to reach or pass through.

3. What features of practical road-building should be kept in view in laying out the line of a road?

Ans. The distance, nature of soil, cost, and ascent and descent of the finished roadway.

4. What is the most desirable way between two places?

Ans. The shortest and most direct, if no serious obstructions interfere.

5. What are some of the obstructions and barriers to be overcome and avoided?

Ans. Hills, hollows, streams, swamps, or other undesirable conditions.

6. To what should the straightness of a road be subordinate?

Ans. The easiness of its rise and fall, in going up over hills and down through hollows.

7. Why?

Ans. Because steep grades, and uphill and downhill places in a road, are perpetual hindrances to the hauling of heavy loads.

8. What is another important feature to be considered in locating a road?

Ans. Its cost, not only of construction, but of maintenance; for instance, it should, as near as possible, be laid out so that the earth from the cuts will make the embankments.

9. Is the shortest road always the cheapest and best?

Ans. Not necessarily.

10. Why?

Ans. Because, by going around hills and hollows, expensive work and steep grades may sometimes be avoided.

11. What surveys are usually made in locating a road?

Ans. Reconnaissance, preliminary survey, and locating survey.

12. What is meant by reconnaissance?

Ans. An examination of the conditions, watercourses, hills, valleys, and soil formation of the country, with a view to alignment, grades, and cost of construction.

13. What instruments are generally used?

Ans. The pocket compass, the tape, and the field glass.

14. What is the alignment of a road?

Ans. Its ground plan, or the directions, angles, and bearings of its course.

15. What is the preliminary survey?

Ans. An experimental survey made with the compass or the transit to determine the bearings or directions; and with the level to determine the comparative elevations or depths of its hills and valleys.

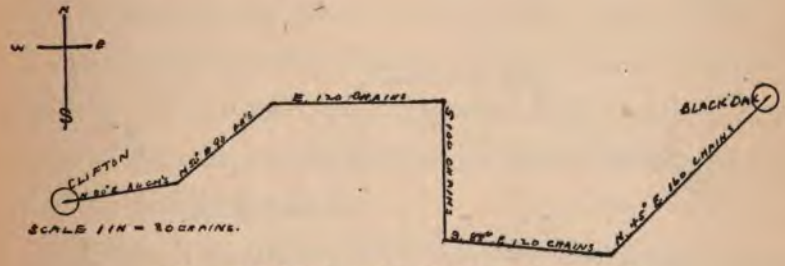
16. What is the locating survey?

Ans. That which corrects any errors in the preliminary or experimental survey, and determines the final location of the road.

CHAPTER IV

THE MAP

THE map and profile in scientific road-building are twin necessities, being indispensable requirements, if the road and its grades are to be systematically located and constructed, so as to be recorded for future reference; but we will for brevity and convenience treat them separately.



MAP SHOWING BEARING OF ROAD
Located with Compass

The map shows the distances and directions of the road: the distances in chains or miles, and the directions by the magnetic bearings of the several turns in the line

of the road, or in angles, right or left, as has been explained in the chapter on location.

A surveyor's chain, known as Gunter's chain, is sixty-six feet long, and is divided into one hundred links; and it takes eighty chains to make a mile, a mile being five thousand two hundred and eighty feet long.

The chain generally used by civil engineers is marked in feet, and is one hundred feet long, divided into tenths of a foot; fifty-two such chains and eighty feet make a mile.

MAP SHOWING ANGLES RIGHT AND LEFT
Located with Transit

The survey of a road should be so shown on the map as to convey to the instructed eye the complete and comprehensive idea of the ground over which the road has been located. It should also be surveyed and recorded

with such accuracy as to its bearings and distances, that any surveyor or engineer may be able at any time to retrace the line of the road and determine, without question, where it was originally located. Road lines very often affect property lines along its course.

The map should also show, as near as possible, all streams, property lines, road-crossings, section lines, etc., crossed by the road and, where possible, the hills and valleys on or adjacent to the line, as well as public buildings, for identification on the profile, which will show them accurately.

The map should always be drawn to a scale; that is, in the same proportion that the distance on the map is to bear to the distance on the ground itself; such as one inch to the mile, or one inch to one thousand feet, or one inch to eighty chains.

This scale must be determined by the draughtsman before he begins to draw the map, and it must not be changed on any part of the same map. However, the scale may be changed to suit the size of the paper or the convenience of the draughtsman for each separate map drawn.

QUESTIONS

1. What is the use of the map of a road?

Ans. To show the distances and directions of the road, which should all be recorded for future reference.

2. How is the length of a road measured?

Ans. In chains or miles.

3. Is there any difference in the length of chains?

Ans. Yes; the surveyor's chain, known as Gunter's chain, which is sixty-six feet long; and the engineer's chain or tape, which is one hundred feet long.

4. How many feet in a mile?

Ans. Five thousand two hundred and eighty feet.

5. How many surveyor's, or Gunter's, chains in a mile?

Ans. Eighty surveyor's chains.

6. How do you know this?

Ans. Because sixty-six feet, the length of the chain, goes eighty times in five thousand two hundred and eighty feet, the length of a mile.

7. How many engineer's one hundred-foot chains in a mile?

Ans. Fifty-two chains and eighty feet.

8. What else should the map show?

Ans. The directions in which the road runs.

9. How are these directions shown?

Ans. By the magnetic bearings, or the angles the road turns to the right or left in its course.

10. Why is it important to survey and record accurately the course of a road?

Ans. Because the bearings of a road may oftentimes affect the property lines along its course, and should be so recorded that any surveyor or engineer may retrace the original course of the road in the future.

11. What should a map show besides the bearings and distances of a road?

Ans. All streams, property lines, road-crossings, section lines, etc., crossed by the road.

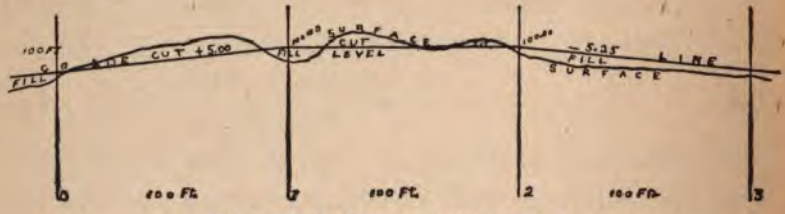
12. What else?

Ans. The hills and valleys, if possible.

CHAPTER V

THE PROFILE

THE profile, the twin necessity to the map, should represent, to any desired scale, the relative heights and distances of the various points, hills, and valleys, on the line; in other words, the outline of the surface of the roadway, as it goes up over a hill or down through a valley.



PROFILE OF A ROADWAY

Concisely and briefly, a profile of a road is a representation, or sectional sketch, of its natural surface, cut perpendicularly through its longitudinal line, showing the relative difference in heights, or rise and fall, of the surface of the road, as it extends over hills and across valleys.

The profile is necessary to guide the engineer, both in determining the ascent and descent of the grade line, and the equalizing of the number of yards of earth or rock in the cuts and fills.

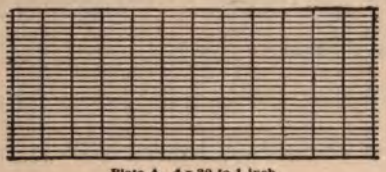


Plate A. 4 x 20 to 1 inch

PROFILE PAPER.

Profiles are usually made on what is known as profile paper,— a paper ruled horizontally with fine parallel lines representing one foot in height, and parallel vertical lines equidistant apart, representing ten feet in length, or any multiple of ten feet, such as one hundred feet, at the convenience of the draughtsman.

As the engineer ascertains the bearings and angles of the road with the compass or transit, so does he ascertain with the level the comparative heights or elevations of the surface every one hundred feet apart, or less if very great irregularities of surface occur.

He then so applies these elevations to this graded or

scaled profile paper as to show the relative heights of all points on the line of the road, so as to establish the grade line and calculate the number of cubic yards of material to be removed, to make the necessary cuts and fills in building the required road-bed on the easiest and most practical grades.

The scale of the profile paper is not the same for distance as it is for elevation. The reason for this is, that the distance is always so much greater in comparison to the changes of elevation of the surface, as the hills and hollows are traversed, that it would be almost impossible to draw them for miles on the same scale; and, moreover, the changes of elevation would be hardly visible to the eye. Consequently, to overcome this difficulty and adapt the profile to the practical use of the engineer, the vertical or elevation scale is usually about ten times that of the horizontal or distance scale. Such an exaggerated scale is known as a standard profile scale, with which all engineers and road builders become familiar.

In some instances, for convenience, the distance scale is reduced to even one hundredth part of the vertical

scale; that is, it makes one foot in height one hundred times as great as one foot of length. On this profile the engineer then determines the grade of the line, which is its longitudinal slope, or rise and fall, in feet, per one hundred feet in distance.

On it also are determined and noted the natural water-courses and the kinds and sizes of bridges and culverts necessary to carry the surface water across the roadway.

QUESTIONS

1. What is a profile?

Ans. The outline plan of the vertical heights and longitudinal distances along the surface of a roadway, railroad, or canal.

2. How are profiles made?

Ans. On specially prepared profile paper, ruled to a scale.

3. What should a profile show?

Ans. The relative heights, in rise and fall, of the road.

4. Is the scale of profile paper the same vertically, or in heights, as it is horizontally, or in distance?

Ans. It is usually not the same.

5. Why?

Ans. Because the distance, or length, is always so much greater than the changes in the elevations of the surface that the changes of elevation would be too small to be of any practical use in determining grades and quantities of material to be moved.

6. What use does the engineer make of the profile?

Ans. On it he determines by actual measurements, the easiest and most practicable grades on which to construct the roadway.

7. What else?

Ans. He also uses it to calculate approximately the quantities of earth or rock or other material, to be moved in building the road.

8. What else?

Ans. To determine the natural watercourses, and the kinds and sizes of bridges and culverts necessary to carry off the water and properly drain the roadway.

CHAPTER VI

GRADES

THE meaning of the term *grade,* as used by civil engineers, is not the roadway, nor cut, nor fill, as is so commonly used by those not engineers, but it means the rise and fall of its surface in vertical feet in each one hundred feet of length, as the road is extended uphill or downhill.

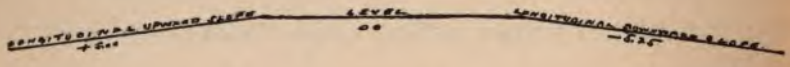
The grade line is an imaginary line down to which all surfaces above it are to be cut, and up to which all surfaces below it are to be filled.

This rise and fall of the grade line is usually referred to as the "percentage of grade."

Percentage means per one hundred, or by the hundred. Every one seems to understand readily the interest or percentage on money; there is no difference in the percentage of money and the percentage of grade, except that one is in dollars and the other is in feet.

If one speaks of one per cent for money, he means

that he is paying one dollar per hundred dollars for the use of the money; if he speaks of paying seven per cent, he means that he is paying seven dollars per one hundred dollars for its use; and if an engineer speaks of a one-per-cent grade, he means that the roadway rises or falls one foot in every one hundred feet; and the same rule applies to any percentage of grade, as a five-per-cent grade, or a seven-per-cent grade.



ASCENDING, LEVEL, AND DESCENDING GRADE LINE

(Plus 5.00 means it is ascending at the rate of five feet in the hundred; minus 5.25 means it is descending at the rate of five feet and three inches in the hundred.)

We have explained that the grade rises or falls so many feet, as indicated, in every one hundred feet. This rise or fall does not have to be so written every time, but is termed a plus or minus grade. The plus grade is the ascending grade, and the minus grade is the descending grade. They are denoted, for convenience, by the algebraic signs + (plus) and — (minus).

For instance, a rising grade of five per cent is denoted

by the sign + 5.00, the sign + indicating that it is rising, and the figures 5.00, after the sign, denoting the rate at which it rises.

Engineers, for expediency and convenience, always figure in decimals, so that a descending or downhill grade of five feet and three inches in the one hundred feet would read — 5.25, denoting that the grade was descending, and doing so at the rate of five and twenty-five hundredths feet in the one hundred feet in distance.

The grade of a road is such an important matter, and has such a continuous and constant effect on the travellers that the young students can not be too greatly impressed with it. It is evident to even the smallest boy or girl that a team can not travel as fast, nor pull as heavy a load, up a steep hill as it can on a level or slightly inclined road.

So the grade affects the speed of travel and the amount that can be hauled; or, in other words, the uphill grade consumes time and decreases the volume or capacity of haul. This, in turn, affects the farmer especially in a commercial or money way, as he wastes his valuable time in not being able to get over the road quickly; and the

less he can haul on his wagons the more it costs him to get his products to market.

This matter of the steepness of grades is so important that the law in some States seeks to control it even on the country roads, by fixing by law a maximum grade; that is, the steepest grade or ascent allowed, above which a permanent road can not be built.

The grades in all cities are fixed by ordinance for the protection of the property owners; and in some States and counties there is a maximum grade fixed even for the principal country roads; that for the neighborhood roads of less importance, being allowed a greater steepness than the main roads.

It will be noticed that there is no law controlling a minimum grade for the same reason that there is no law governing good deeds; a maximum grade may be so steep as to make a road almost impassable, while a minimum grade can not do more than reach the level plane, the easiest travelled road, hence the ideal road, so far as grades affect it.

Very steep grades also affect the maintenance of a road very seriously, as it is often the cause of the most

A ROAD IN NEW YORK, WHOSE GRADE WAS CHANGED FROM 21 TO 5 PER CENT. BY SKIRTING THE HILL TO THE RIGHT

ON A POOR ROAD, A TEAM HAULS ONLY ONE BALE OF COTTON TO MARKET

ON AN IMPROVED ROAD, A TEAM HAULS ELEVEN BALES OF COTTON TO MARKET

damaging washing of the side ditches, ruts and road-bed, often cutting little gullies and crevasses in and across the roadway, which necessitates constant and costly repairs.

To show the importance that the steepness of the grade is to the traffic over a road, we will submit a table showing the comparative loads that can be hauled with the same force or energy over certain grades.

If a team can haul four thousand pounds on a level road, it can haul with the same effort the following loads in pounds:

Per cent of grade.	Pounds.
On a level, or 0.00	4,000
1 per cent., or 1 ft. in 100 feet	3,600
2 " " or 1 ft. in 50 "	3,240
2½ " " or 1 ft. in 40 "	2,880
4 " " or 1 ft. in 25 "	2,160
5 " " or 1 ft. in 20 "	1,600
10 " " or 1 ft. in 10 "	1,000

Think of it! If a man has a team that can take 4,000 pounds to market on a level road, but happens to have a hill rising one foot in twenty-five feet, which is very common, he must leave 1,840 pounds at home,— nearly

half of his load; or if he has a hill rising five feet in one hundred feet, or a + 5.00 grade, he must leave 2,400 pounds, or over half at home, as he can haul only 1,600 pounds over such a hill.

PULL OF COMPARATIVE LOADS ON RELATIVE GRADES WITH SAME POWER

(Scale: 25 ft. to 1 inch horizontal; 5 ft. to 1 inch vertical). This diagram will more clearly illustrate the foregoing table of wasted energy as a grade gets steeper and steeper, resulting in increased cost of haul or injury to animal.

There are, however, many hills on our country roads that it takes a ten-per-cent grade, or ten feet in one hundred, to get over, and he must then leave three-fourths of his load at home, or strain his team, as, with the same effort, they can haul only 1,000 pounds over such a grade.

These hills and steep grades are so disastrous to traffic that highway engineers always try to change an old road to avoid them, as will be shown in the preceding illustration.

It should be here briefly stated that in cities where permanent grades are established by ordinance, an ordinance also has been previously passed establishing and recording the assumed height of a fixed and immovable stone known as the "Datum Stone," from which all other elevations are calculated, and to which they all refer.

On a country road, the engineer, when taking the levels for his profile, selects or prepares a permanent point on a tree, ledge of rock, house foundation, or other suitable place, which he gives an assumed elevation, say five hundred feet, which he records and describes on his notebook, and later on his profile, for the information and guidance of those who may be called upon in the future to retrace his line of elevations.

QUESTIONS

1. What is meant by grades?

Ans. The grade of a road is the rise or fall of its surface as it goes uphill or downhill.

2. How is the grade of a road measured?

Ans. By the rise or fall in vertical feet; that is, up or down, in every one hundred feet of length.

3. What is the term used to denote that grade?

Ans. The percentage.

4. Explain the percentage of a grade.

Ans. Percentage means per one hundred, or by the hundred.

5. Compare the percentage of grade with the percentage of interest on money.

Ans. The percentage on money is the number of dollars paid on every hundred dollars for the use of the money; the percentage of grade is the rise or fall in vertical feet for each one hundred feet of length of road.

6. What, therefore, is meant by a two-per-cent grade?

Ans. That the road rises or falls two feet in every one hundred feet of length.

7. Explain a five-per-cent, or a seven-per-cent grade.

Ans. It rises or falls five or seven feet vertically in every one hundred feet of length.

8. How is this percentage denoted as to rise or fall?

Ans. By the algebraic sign for plus or minus.

9. How are these signs written?

Ans. + or —; termed plus or minus.

10. What does the sign + (plus), mean?

Ans. That the slope is upward.

11. What does + 2, or + 5, or + 7 mean, when written on the grade line of a road?

Ans. That the slope is uphill, two or five or seven feet in the hundred feet of length.

12. What does the sign — (minus), mean?

Ans. That the slope is downward.

13. What does the sign — 3, or — 4, or — 6 mean?

Ans. That the slope is downhill, three or four or six feet in the one hundred feet.

14. How does the engineer figure, and why?

Ans. In decimals, for expediency and convenience.

15. How does the upward grade on a road affect the passage or hauling over it?

Ans. As a team can not travel as fast, or haul as heavy a load, up a steep hill as it can on a level or slightly inclined road, it affects both the speed of travel and the amount that can be hauled over it.

16. Can you express this in fewer words?

Ans. It consumes time and decreases the volume or capacity of haul.

17. How does this especially affect the farmer commercially, or in a money way?

Ans. It wastes his time; and it increases the cost of hauling his products to market, thereby decreasing his profit.

18. Does the law recognize grades on the streets of a city or on the roads in the country?

Ans. Yes; in all cities on the streets, and in some States on its principal country roads.

19. How?

Ans. The grades, or rise and fall, of its streets or roads are proposed by the engineer and approved and adopted by ordinance in a city, or by enactment in a State or a county and are recorded for guidance in the future.

20. What other terms are used regarding grades?

Ans. The maximum and minimum grades.

21. What does maximum mean?

Ans. Greatest.

22. What does minimum mean?

Ans. Least.

23. What do maximum and minimum mean as applied to grades?

Ans. Maximum means steepest, or greatest rise or fall, per one hundred feet; and minimum, the least rise or fall.

24. Are there ever laws governing these two extremes of grades?

Ans. Yes; governing the maximum, but never the minimum.

25. Why this difference?

Ans. Because the maximum, or steepest grade may become a barrier to travel and traffic and should be limited; whereas the minimum grade necessarily stops at the level plane, the ideal and best road, and needs no governing law or restriction.

26. To what is this likened?

Ans. The legal restrictions against evil-doing; while there is no law against good deeds.

27. How else does a steep grade affect a road?

Ans. It causes the side ditches, ruts, and road-bed to wash, cutting little gullies and crevasses in and across the road.

28. What does this specially affect?

Ans. The maintenance and cost of repair of the road.

29. How are the elevations for the established grade permanently fixed?

Ans. In cities by a fixed and immovable stone, whose elevation is recorded.

30. What is this Stone called?

Ans. The city "Datum Stone."

31. Where may assumed elevations be preserved on country roads?

Ans. On a fixed, immovable point on a tree, ledge of rock, house foundation, or other suitable place.

32. How are these elevations preserved?

Ans. They are recorded in the engineer's note-book, later on the profile, and also in the proper county records.

33. Why is this done?

Ans. For the guidance of any engineer who may have to retrace this line of elevations in the future.

CHAPTER VII

DRAINAGE

DRAINAGE, or draining, as applied to roads and the adjacent slopes, or, in simpler words, getting rid of the surplus water that runs onto, across or down a roadway, is the art or method used in taking away the surplus water arising from rain-falls, and that which accumulates on the roadway from the adjacent hill-sides, or from the seepage from under-ground springs, soggy conditions, or other sources under the roadway.

The final and successful disposal of this accumulated water is one of the many important problems that confront the highway engineer and road builder.

The drainage question is one of vital importance to the maintenance of any road, on account of the damaging effects of water running down or over a road, whether an earth road, a plank road, or even a rock road; for it is well known that dripping or running water will eventually wear away even a stone. It is the direct cause of more costly repairs than any other

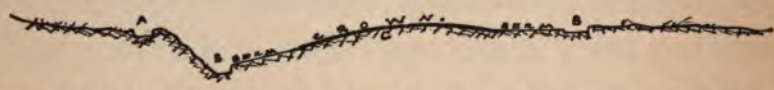
source of wear and tear on a road-bed; it also means more constant watching than all other sources combined.

Even the grade of the road, as explained in the preceding chapter, has to be determined upon and established with a view to its proper drainage; for while any descending grade will assist in the drainage of the road, a stretch of level road may be so long as to retard materially the natural flow of the surface water, forming muddy conditions or even pools of water along the road-side, which naturally keeps the road-bed itself in a soft and soggy state, ending in deep ruts and mud-holes.

Then again, a grade may be so steep as to cause a rush of water down the side ditches that seriously damages the road-bed by washing and cutting its ditches into little gullies and crevasses, the care and constant filling of which add enormously to the expense of maintenance.

First of all, every hill-side draining toward the roadway should have what is known as a berm ditch; that is, a ditch cut several feet back from the edge of the upper side of the cut through which the road passes,

in order to divert the water running down that slope to the natural drain at the foot of the hill, and prevent it from running over the side of the cut into the roadway, and from washing the earth from the side of the hill into the ditches on the side of the crowned road-bed.



A. BERM DITCH, ON UPPER SIDE OF CUT; B-B. SIDE DITCHES, ON EACH SIDE OF CROWNED ROAD-BED; C, CROWNED ROAD-BED.

The above cross-section shows a berm ditch, berms, crowned road-bed, and side ditches of roadway running through a cut.

The crowning of the road-bed is one of the features of good drainage, as where a road-bed is well crowned the rain water runs off to the side drain ditches as soon as it falls, and does not soak into the earth, as it otherwise would.

Every roadway should be provided with side ditches leading to the nearest natural watercourse across the roadway, and they should be wide, flat ditches, and of ample size to carry off the heaviest rain-fall that will

reach the road, so as to keep the road-bed drained and dry at all times.

Besides the necessity for side ditches, carrying the water to the natural watercourses, however, the ample size of the openings to waterways crossing under the roadway, which should always be of a permanent character, is of the greatest importance; for the side ditches become useless unless the area of the waterway is sufficiently large to carry it off at once, as it would soak into and under the road-bed, doing vast and costly injury.

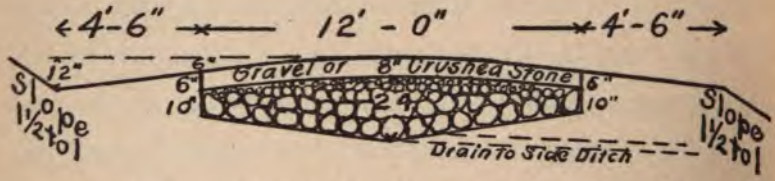
It is very much better, however, to have too much opening for a culvert than too little; so if a road builder can not calculate the necessary area of a culvert, he had better pay a competent man to do it for him, or be guided by some prepared table, showing the proper size of openings for draining certain areas of land.

The area for a waterway is calculated from the number of gallons of water that fall on that area in the different rain-falls, for example, a one-inch-per-hour rain,— and then finding the velocity of the flow of water according to whether the fall toward the outlet is very

flat or steep; and the proper allowance should be made for evaporation and absorption; and the opening should be made sufficiently large to take off the water without backing up or overflowing.

The most difficult problem, however, is where seepage water or a soggy sub-soil is encountered under the roadway, keeping the road-bed wet and boggy at all times.

There is but one surely successful treatment for this, and it has to be resorted to, although very expensive, if a dry, hard, and compact road-bed is expected, and that is sub-drainage.



SUB-DRAIN ON V-SHAPED SUB-GRADE, SHOWING SUB-DRAINAGE TAKEN TO SIDE DITCH

By sub-drainage is meant a system of draining under the road-bed and continued down the road until the soggy, wet place is passed, when the drain should be

OLD VERMONT ROAD, WHOSE BOGGY CONDITION WAS DUE TO SEEPAGE

THE SAME ROAD, IMPROVED BY [illegible]NAGE, AS ELSEWHERE DESCRIBED

brought out to the surface at some naturally drained place.

Briefly, sub-drainage is the common term for an under-ground drain. This is made by digging a ditch down the middle of the road, partially filling it with some porous or open material, such as broken stone or brick-bats, or with porous hollow tile or sewer pipe, then re-filling and tamping. The seepage water then seeks an outlet through this hollow pipe to the end, where it empties into the creek or other natural drain, leaving the road-bed dry and hard.

QUESTIONS

1. What is meant by the drainage of a road?

Ans. Getting rid of the surplus water that would otherwise run down or across the roadway.

2. If it were not drained off, what would be the result?

Ans. It would wash the ruts into gullies, and accumulate in the low places in the road or along the road-side.

3. What would then happen?

Ans. The road-bed would be kept wet and boggy, and mud-holes would form.

4. What is the usual method of drainage?

Ans. A wide, flat ditch on each side of the crowned road-bed to take the water to the nearest natural drain.

5. What is a crowned road-bed?

Ans. A road-bed that is curved from side ditch to side ditch, so that the water will run at once into the ditches instead of soaking into the road-bed and softening it.

6. What is meant by natural drains?

Ans. The valleys and low places through which the water runs to the creeks and rivers.

7. Is there any danger of water from the hill-sides running onto the roadway?

Ans. Yes; it always does, if not stopped.

8. What damage would it do, especially if the roadway were through a cut?

Ans. It would wash the earth from the sides of the cut into the ditches and fill them up.

9. Would this cause any especial expense or work?

Ans. These ditches would have to be cleaned out after every rain or snow, adding very much to the cost of keeping up the road.

10. How could this be prevented?

Ans. By digging a berm ditch several feet back from the edge of the cut on the up-hill side to catch the water and carry it to the foot of the hill or to a natural watercourse.

11. What water are these side ditches intended to take off?

Ans. The natural rain-fall or surface water.

12. What other drainage problem has the road builder to contend with?

Ans. Seepage water that happens to be under the road-bed.

13. What causes seepage water?

Ans. An under-ground spring, or the water from it oozing through the earth making its way to some natural water-way or creek.

14. How is this overcome?

Ans. By sub-drainage sufficiently far down the road to take the water away from the roadway.

15. What is meant by sub-drainage?

Ans. A drain under the ground.

16. How is this drain made?

Ans. By digging a ditch down the middle of the road until it passes the part affected by the under-ground water; then filling it with loose stones or brick-bats; or, better than that, with hollow tile, filling up the ditch and thoroughly packing the earth over it.

CHAPTER VIII

CROSS-SECTION

THE cross-section of a road bears the same relation to a line from one side of the roadway to the other, that the profile does to the longitudinal line, showing the changes of its surface elevations. This should be explained and discussed, to familiarize the child with

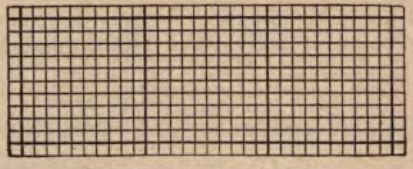


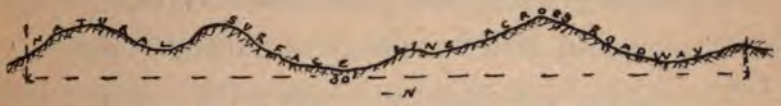
Plate F. 10x10 to the inch

CROSS SECTION PAPER

a technical term as commonly used by road builders and railroad men as is the term profile, and should be understood by the embryo road builder, the school boy or girl of to-day, the man or woman of to-morrow.

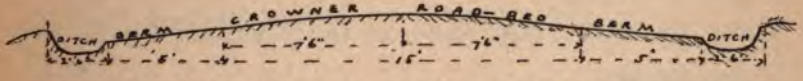
Imagine a thirty-foot roadway cut perpendicularly across its entire width from side to side, so that you can see the top edge, or surface line with its irregularities

as nature made it, and you will have the cross-section, thus:



CROSS-SECTION. NATURAL SURFACE

Then imagine the same surface line improved,— a permanently improved roadway, as is shown below, and you have the cross-section of the roadway so improved as to have side ditches, berms between the ditches and road-bed, and the crowned road-bed.



CROSS-SECTION. FINISHED ROAD

Usually the crown of a road-bed is convex, like the one shown, but occasionally in very narrow roads where it is impracticable to have the ditches on either side, and where the surface is covered with some hard and durable material, such as asphalt, brick or granitoid, the crown is inverted and becomes concave, taking off the rain-fall through the middle line or lowest place in

the concave or hollow surface. This is done usually in paved alleys in cities.

There are practical and philosophical reasons for the arrangement of such a roadway as illustrated above.

The ditches are designed to drain the roadway and take off the surface water as fast as it falls, to the nearest natural watercourse, where it can be led away entirely.

The berms, or gently sloping portions on either side of the finished road-bed, are designed to protect it, as well as to keep the wheels from cutting the ditches and filling them up, and are sloped toward the ditches to carry the water that falls on the road-bed to the side drain-ditches.

The road-bed is curved, or "crowned," to draw the rain-fall to the berms and ditches, in order that it may always remain dry and hard to resist the wear of the wheels.

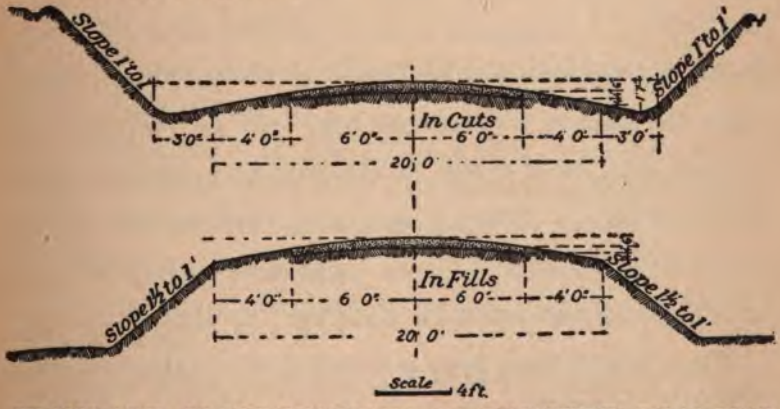
In short, the whole plan is designed to drain the roadway into the ditches, and through them on to the nearest natural watercourse.

These side ditches should be wide and shallow, for

the reason that narrow, deep ditches would soon fill up and fail to do the intended work of drainage. They should be about one foot deep and from two and a half to four feet wide on top, with sloping sides, according to the width of the entire right-of-way allowed the road.

The berms should be from four to six feet wide, according to the width of the right-of-way; and the crowned road-bed from eight to fifteen feet, or more, in width.

The first illustration, giving natural surface and finished roadway, shows a thirty-foot right-of-way, with a fifteen-foot road-bed, five-foot berms, and two and one-half-foot ditches.



STANDARD CROSS-SECTIONS OF FINISHED ROADWAY

The preceding illustrations show the finished roadway, on a standard cross-section: the first, through a cut, showing the sides of the cut slope one foot out to one foot in height, the usual slope for such work, finished to a width of twenty-six feet, including the two side ditches. We also call attention to the berm ditches at the top of the side of the cut.

The second illustration shows the same cross-section on an embankment where, no ditches being necessary, the total width is only twenty feet, and the sides of the embankment sloped one and a half out to one foot high, the natural slope of loose earth.

Each cross-section shows a twelve-foot Macadam road-bed.

An eight-foot road-bed will take any vehicle, but it takes at least a fifteen-foot road-bed for two vehicles to pass safely and easily, so it would be a waste of space and expense to make it over eight feet unless it were made wide enough for two wagons to pass; that is, it should be the fifteen-foot road-bed, as shown.

Some States have laws governing this feature of road-building, stipulating that road-beds shall be no less than

eight feet, and not over sixteen feet wide, unless a good and justifiable reason for the extra expense can be shown the Court.

QUESTIONS

1. What is a cross-section of a road?

Ans. It is a profile of a line across the roadway at any given point.

2. What does it show?

Ans. Before the road is improved it shows the profile of the road across its original or natural surface at the point selected.

3. What does it show when improved?

Ans. It shows the profile across the same road as it should appear when completed, showing side ditches, berms, and crowned or curved road-bed.

4. Why is the road-bed curved or crowned?

Ans. To run the water off into the side ditches before it soaks into the road-bed.

5. What would be the result if the road-bed were not crowned?

Ans. The water would soak in and soften the surface, and the wheels would cut deep ruts and mudholes.

6. What are the berms?

Ans. Slightly sloping spaces between the crowned road-bed and the ditches.

7. Why are the berms left, and which way should they slope?

Ans. They should slope toward the ditches; they are left to

keep the wheels from cutting and filling the ditches and also as a protection to the crowned road-bed itself.

8. Why are the ditches made on either side?

Ans. To take the surface water away from the road-beds and berms as rapidly as it falls, to the nearest watercourse.

9. What sort of ditches should be made?

Ans. Wide, shallow ditches, that will not cave in, and that can be easily cleaned out when necessary.

10. What widths of berms are most desirable?

Ans. As wide as the right-of-way of the road will permit, but not less than four to six feet wide.

11. What widths are used for road-beds?

Ans. From eight to fifteen feet, or more.

12. Why?

Ans. Because an eight-foot road-bed is wide enough for any vehicle to travel on, and a fifteen-foot one is wide enough to admit of two wagons passing.

13. Why would it be a waste to have it between eight and fifteen feet wide?

Ans. Because nothing would be gained by having the improved road-bed wider, unless wide enough for two vehicles to pass.

14. Are there laws governing this feature of road-building?

Ans. Yes; in some States the law provides for an improved road as narrow as eight feet and not over sixteen feet, unless good reasons are presented to the Court for making it over sixteen feet.

CHAPTER IX

BIDDING ON AND CONTRACTING FOR THE WORK

IN preceding chapters we have shown, by the map, the directions and distances of the roadway; by the profile, we have shown the surface and grade lines along the middle of the road, showing also the necessary cuts, by the surface line above the grade line on which this road is to be constructed; and the necessary fills by the surface line below the grade line up to which the roadway is to be built; and by the cross-section, the irregularities of the surface across the roadway, as it is found, and the cross-section of the roadway when built according to the map and profile.

When prepared by a competent highway engineer, these three features of road-building are usually all that are necessary to enable a contractor or road builder to make an approximate estimate on which to base any bid that he should be called upon to make, at definite prices per cubic yard, or for the whole work completed, according to plans and specifications.

If a contractor bids on all the earth and rock-work on a road at a stipulated price by the cubic yard, the engineer is required to make an accurate measurement of the amounts in the various cuts and fills and ditches.

If the contractor bids for the work as a whole, completed according to the map, profile, cross-section, and specifications, then the engineer is expected to draw up specifications, of which the map, profile, and cross-section are made a part by reference thereto, naming every item of the work and stipulating how each and every part of the work is to be constructed and completed, according to the several plans above described.

The contractor then makes a contract for the work, with the engineer or other proper authority, of which the specifications and several plans become a part, and gives a bond for the faithful performance of his work, according to plans and specifications, and under the supervision of the engineer or other competent person appointed to see that he carries out the provisions of his contract.

If the work is not to be let by contract and at stipulated prices per cubic yard or for the whole, then it is

done under the supervision of the highway engineer, or road overseer, at the actual cost of construction; an accurate and itemized account of which shall be kept and reported to the proper authority, and charged against the road district in which the improvement is made.

Before bidding, the contractor should make an estimate at what price per cubic yard he can afford to undertake the work.

By experience or by experiment, he finds out how many cubic yards of the several materials, earth, loose rock or solid rock, can be moved by a man or a team in a day, and knowing the current price of labor, he knows how much per cubic yard the work will cost him.

The work is sometimes shovel work, but oftener wheelbarrow, scraper, cart, wagon, or other team work; therefore he should familiarize himself with the amounts that can be done in a day by each of the several methods to be employed, as well as knowing which kinds of the several materials can be handled to the best advantage with the plough and scraper, which kind can be more advantageously handled by wheel scrapers or wagons, and how much will have to be blasted with powder or

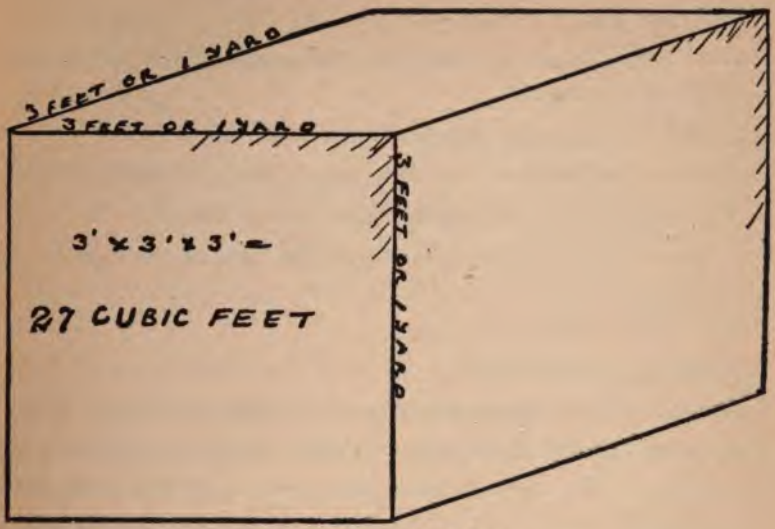
dynamite, before venturing to bid on or contract for work.

After this, he is in a position to estimate what will be the actual cost of construction to him, to which he adds such profit, and percentage for incidental expenses as he feels is safe and proper; and on this basis he makes his bid and contract.

So it is very evident that a contractor, before he undertakes to contract and give bond for the faithful performance of such work, should be as familiar with the terms, appliances, and methods of calculation and construction, and the classification of materials, as the engineer.

By the term cubic yard is meant a solid body of earth, or other substance, three feet, or one yard long, one yard broad, and one yard thick.

As three feet is the measure of each of its three dimensions, and the three multiplied together make twenty-seven, a cubic yard of earth contains twenty-seven cubic or solid feet. So if you wish to find the number of cubic yards, you divide the number of cubic feet by twenty-seven, or three times by three.



ONE CUBIC YARD

QUESTIONS

1. By whom are roads built?

Ans. Either by a contractor at a price agreed on, or by the appointed road overseer at the actual cost of construction.

2. Under whose supervision should improved roads be built?

Ans. Under the supervision of the highway engineer, or other competent person appointed for that purpose.

3. What things guide the road builder in his work?

Ans. The map and profile, as to length; the profile, as to required cuts and fills; and the cross-section, as to the final shape of the roadway.

4. What else?

Ans. A specification drawn for that purpose, determining all features of the work.

5. What is a specification?

Ans. A specification is a document, naming each and every item of work, and describing how it is to be performed.

6. How is the road district safeguarded against error or fraud in doing this work?

Ans. By a contract and bond.

7. What is a contract?

Ans. A written agreement between the representatives of the road district and the contractor, in which are stipulated the several items of the work and the price to be paid for same, and his agreement to do them in accordance with the stipulations.

8. What is a bond?

Ans. A bond is a document, wherein the contractor gives responsible security, by a bond company or by individuals, that he will faithfully and honestly complete his work before he is paid fully for same.

9. What if the road is built by the road overseer?

Ans. He should keep an accurate and itemized account of the work, and report the same to the proper authority for record.

10. How is this work then paid for?

Ans. Out of the road tax of the district in which the road is built.

11. What is meant by cubic yard?

Ans. A solid body with its length, breadth, and thickness each three feet, or one yard.

12. How many cubic feet in a cubic yard?

Ans. Twenty-seven.

13. Why?

Ans. Because the multiplication together of the three feet on each side makes twenty-seven.

14. If you have then the number of cubic feet in a cut or fill, how do you know the number of cubic yards in it?

Ans. By dividing the amount by twenty-seven, or three times by three.

15. What should a contractor do before bidding on work?

Ans. He should familiarize himself with the cost of doing the various kinds of work to be done, calculate the amounts, and make an estimate of same.

16. What then?

Ans. He should add a safe and proper percentage for incidentals and profit, on which he bases his bid and contract.

CHAPTER X

STAKING THE WORK

FOR the purpose of measuring the distances and for identification on the profile, so far, the only stakes driven are those marking the middle line of the road. These stakes are driven one hundred feet apart and are marked numerically in plain figures, commencing with 0 and continuing 1, 2, and so on. The places are called "stations"; and if, on account of unusual irregularity in the ground surface, other stakes are driven at any points between two such stations, those places are called "plus stations" and are marked with the plus sign before the figure, indicating the distance, thus + 37 or + 81, as the distance may be. These plus stations are noted for the purposes of estimating the yardage and for locating the irregularities on the profile.

After the work is contracted for, the next duty of the engineer is to stake off the work; that is, to make the necessary measurements at each station or cross-section, and drive stakes in the middle and at each side,

plainly marked, showing the number of the station on the outside and on the side toward the middle line the depth of the cut or height of the fill or embankment, using before the figures the letter *C.* for cut, and *F.* for fill, thus:"C. 2.13," indicating a cut of two feet and thirteen hundredths; or "F. 6.21," indicating a fill of six feet and twenty-one hundredths.

If there is neither cut nor fill, the ground being at grade, the stake is simply marked "0.00."

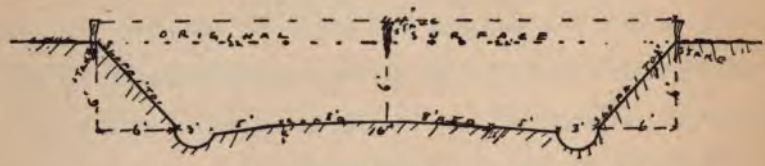
The stake at the middle line is always on that line, but the side stakes vary as to the distance they are set out from the middle stake.

The reason for this is, that if it is in a cut, the slope of the bank is only one foot out to one foot of cutting; while if in a fill, the slope is one and a half feet out to one foot in height, one and a half to one being the natural slope of loose earth.

Of course this slope may be varied, as the slopes of banks and loose earth are often increased to meet unusual conditions.

For the side stakes the distance out is calculated thus: take one-half of the road-bed; add to it the berm, if

any; add to this the width of the ditch, and then add, if in a cut, the slope which at one to one would be the same as the height.



SIX-FOOT CUT ON LEVEL GROUND

For instance, in a cut six feet deep, with a sixteen-foot road-bed, five-foot berms and three-foot ditches, on a level cross-section, the distance out would be, one-half of the road-bed, or 8; plus the berm, or 5, equals 13; plus the ditch, or 3, equals 16; plus the slope, or 6, equals 22 feet; therefore, these stakes should be set out twenty-two feet from the middle stake and should be marked, "C. 6.0."

EIGHT-FOOT FILL ON LEVEL GROUND

If the station should be an eight-foot fill, with a sixteen-foot road-bed and five-foot berm, but no ditches,

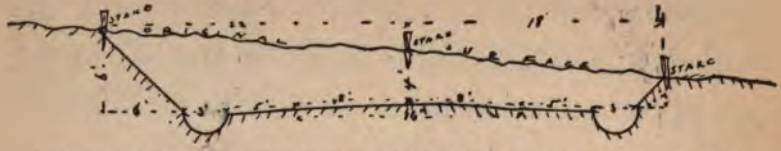
the distance out for the side stakes would be: half the road-bed, 8; plus the berm, 5, equals 13; plus the natural slope of one and a half to one (8 + 4) or 12, equals 25 feet.

These stakes should be set out twenty-five feet from the middle stake, and should be marked, "F. 8.0."

The preceding illustrations and examples are for work that is staked out at a station that is level across the roadway. But there are stations where the cut or fill may be on a side-hill or through a hollow, making the cut or fill on the middle line and sides each different, known as "irregular cross-sections." These stations are staked out by the same rules, except that the allowance in the distance out must be made for the difference in the depth of the cut or height of the fill on the two sides.

Therefore we will give illustrations of only two examples, using the same rules as above described.

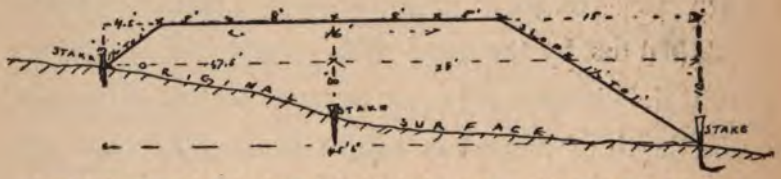
Suppose we have, for illustration, a cut four feet deep on the middle line, while it is six feet deep on the upper side and only two feet deep on the lower side, as the following diagram shows.



IRREGULAR CROSS-SECTION; ON CUT 4 FEET IN MIDDLE

These stakes should be marked as follows: Middle, "C. 4.0"; Right, "C. 2.0"; Left, "C. 6.0."

The following illustration shows the cross-section and stakes for a fill that is eight feet high in the middle, three feet high on the upper side and ten feet high on the lower side, thus:



IRREGULAR CROSS-SECTION; ON FILL 8 FEET IN MIDDLE

The middle stake should be marked "F. 8.0"; the left, "F. 3.0" and driven seventeen feet and six inches out from the middle; and the right, "F. 10.0," and driven twenty-eight feet out from the middle stake.

There is also another condition of an "irregular cross-

section" that involves a still more complicated method of staking out, as well as calculation of the areas and quantities of yardage in making the estimate, and that is a condition where there is a fill on one side of the roadway and a cut on the other. This may vary, but we will explain and illustrate the simplest,—one where it is grade in the middle, two feet out on one side, and two feet fill on the other. Keep in mind that the slope on the cut side is still one to one and that on the fill side one and a half to one.

IRREGULAR CROSS-SECTION; GRADE AT MIDDLE; CUT ON ONE SIDE; FILL, ON OTHER

The middle stake at this station is marked "0.0"; that on the fill side is set out sixteen feet and marked "F. 2.0"; and that on the cut side is set out eighteen feet and marked, "C. 2.0."

Besides making these measurements and markings on the stakes, the engineer not only records in his note-book the cuts and fills, but also the distances he has set the stakes out, as such information is absolutely neces-

sary in order to enable him to calculate the exact amounts in cubic yards in each cut or fill, thus:

C. 6.0	C. 4.0	C. 2.0
22.00		18.00

The middle figure indicates the cut at the middle stake; the figure above the line on the left, the cut; that below, the distance the stake was set out; and that on the right, the same. In other words, in case these stakes have been, from any cause, removed or disturbed, his note-book will show that the middle cut was four feet, the left hand cut was six feet, and the stake was driven twenty-two feet out from the middle; and on the right, that the cut was two feet and that the stake was driven eighteen feet out from the middle.

By this he is not only able to make accurate estimates, but he is able at any time to correct an error or detect a fraud, should any one move in a side stake to save work.

When the grading of the roadway has been completed, and the road-bed, berms, and ditches are ready to be shaped exactly to the cross-section, the engineer

may be called upon to give what are known as "grade pegs." A grade peg is a short, strong stake or "hub," driven so that the top of it is exactly at the grade line. These pegs are used by the construction force by which to finish up the work; and after the roadway is properly brought to their level, the engineer, or other authority, goes over the work, examining the widths of the road-bed, berms, and ditches before accepting it or relieving the contractor and his bondsmen from further responsibility.

QUESTIONS

1. What are the first stakes driven on a road?
Ans. The middle stakes.

2. Why are these stakes driven?
Ans. To mark the middle line of the road and its length.

3. How far apart are they driven?
Ans. One hundred feet, usually.

4. Are there ever any stakes driven on the line between them?
Ans. Yes; at any place where great irregularity occurs.

5. What are the places at the regular stakes called?
Ans. Stations.

6. What are those in between called?
Ans. Plus stations.

7. How are the regular stakes numbered?

Ans. Numerically, in plain figures, commencing with 0 and continuing 1, 2, and so on.

8. How are the plus stations marked?

Ans. With the plus sign before the distance from the regular stake; for instance, "2 + 81" for a stake left at eighty-one feet beyond Station 2.

9. Why are these plus stations noted?

Ans. For purposes of calculation, and to locate these irregularities on the profile.

10. What stakes are next driven?

Ans. Those driven in staking out the work.

11. What is meant by "staking out"?

Ans. Indicating, by the stakes at the middle and at the sides, the depths of the cuts and the heights of the fills.

12. When are these stakes driven?

Ans. Usually not until the work has been contracted for.

13. How are they marked?

Ans. In plain figures showing on one side the number of the station, and on the other the cut or fill at such station.

14. How are cuts and fills distinguished from each other, and the depth or height known?

Ans. The stakes for cuts are marked with a *C.* before the figure and those for a fill with *F.* before the figure.

15. Give an example.

Ans. A six-foot cut is marked "C.6.0" and a four-foot fill is marked "F.4.0."

16. Are the stakes in the middle always on the same line?

Ans. Yes.

17. Are those on the sides always the same distance out from the middle stake?

Ans. No; they vary according to the depth of the cut and the slope of its sides; and according to the height of the fill and the slope of its sides.

18. What other features affect the distances out?

Ans. The widths of the road-bed, berms, and ditches.

19. What is the usual slope on the banks of a cut?

Ans. One foot out to one foot in depth, because most earth stands at that slope.

20. What is the usual slope on earth fills?

Ans. One foot and a half out, to one foot in height, because that is the natural slope of loose earth.

21. Are the slopes ever made less or greater?

Ans. In rock cuts they may be made perpendicular. In both cuts and fills, however, the slope may be increased to meet peculiar conditions of the soil or surroundings.

22. What is a regular cross-section?

Ans. One where the cut or fill on each side is the same as in the middle.

23. What is an irregular cross-section?

Ans. One where the cut or fill on the sides is less or greater than that in the middle.

24. Can you tell of another irregular cross-section?

Ans. One where there is a cut on one side of the roadway and a fill on the other.

25. How many stakes are usually needed in staking out work?

Ans. Three; one in the middle and one on each side.

26. How are the side stakes set?

Ans. At the proper distances out to the right and left, to admit of the required road-bed, berm, and ditch, and the slope of the cut or fill.

27. How does the engineer record these cuts, fills, and distances?

Ans. He records in his note-book the cut or fill marked on each of the three stakes, and the distance out he set the side stakes.

28. Why is this important?

Ans. Because by them he calculates the amounts of material in each cut and fill.

29. Of what other importance are these notes?

Ans. To correct any error that may occur, or detect any fraud, if a stake has been moved.

30. What are the last stakes driven?

Ans. The grade pegs.

31. For what purpose are they driven?

Ans. They are driven so that the top of the peg is at the grade line, and it is used by the contractor to finish his work by.

32. When are the contractor and his bondsmen relieved of further responsibility?

Ans. When the engineer has examined the grade pegs, measured the widths of the road-bed, berms, and ditches, and accepted the work as completed.

CHAPTER XI

CONSTRUCTION

AS soon as practicable after the engineer has staked out the work, the actual construction of the cuts and fills should be commenced, for the evident reason that the longer the stakes are left unused, the greater the chance of their being disturbed, causing the tedious work to be done over.

By "construction" is meant the actual performance of the physical work of building the road; removing the earth in those portions where the surface line is shown on the profile to be above the grade line, usually called a "cut" or excavation, and the placing of the earth in the low places, where the surface line is shown on the profile to be below the grade line, commonly called a "fill" or embankment; in other words, bringing all natural surfaces to the grade line, whether by fill or cut, the same to be in shape across the roadway to conform to the cross-section at that point, and doing the work of

both excavation and embankment, for road-bed, berms, and ditches, in accordance with the specifications.

The term "construction" refers not only to the earth or other material to be removed in making cuts and fills, but also to the mechanical structures, such as bridges, culverts, dams, retaining walls, etc., as may be needed or called for in the specifications or plans.

In construction, as in everything else, the cost is a very important feature to be watched, for it will eventually be paid by the tax-payer, whether the work is done by their individual work or let by contract, the bid for the work being based on what the contractor estimates the cost will be; so it is plain, that if he figured on a costly basis, the tax-payer was paying for it, in an indirect way, without knowing it.

Therefore, for the good of the tax-payer, every yard of earth in cut or fill should be moved in the shortest possible time and at the least cost of labor, whether of man, team, or machinery.

For instance: if you are interested in watching a gang of men, such as scraper-fillers and dumpers and shovellers, and the teams, whether in plough, scrapers, or

wagons, and you notice that the teams are so crowded that in every round they make, one team stops for a few minutes waiting for another to go on, you are paying invariably for one team a day more than is needed; or, if on the other hand, the teams are too few and come around so far apart that the scraper-filler and dumper are idle a part of every round, then you are paying for the time of the man while he is doing nothing, waiting for the team. In either of these cases economy suggests that a change be made.

In the first instance, the remedy would be to remove one team and put it at some other work; and in the other, promptly secure another team and add it to the run, for in every case, where the contractor knows his work, he sees to it that each run of men and teams is kept constantly moving, without crowding or over-working man or beast.

That is the strictest economy; and economy of labor and energy is the secret of all successful contractors.

The term "construction" is broad in its meaning, and embraces all the many practical ways of accomplishing the desired end — good roads.

In fact, good roads demand perfect construction; and perfect construction demands all the features covered by the chapters from Location to Staking the Work; for everything from the reconnaissance to the actual building of the road is embraced in that one word.

There are various modes of construction, and it requires many different kinds of tools and machinery which have been provided by the inventive genius of man.

Of course, it takes scientific knowledge and experience to decide how to proceed with this work; oftentimes a contractor with unbounded energy has proven a failure, because he did not possess the knowledge of how best to apply his energies.

The simplest and least expensive work tools are the pick, the spade, and the shovel, worked in connection with the wheel-barrow.

Embankments of from one to two feet high and cuts of corresponding depths, especially where the earth can be pitched into place with one handling, may be cheaply done by this method, which is known as "station work," for the reason that it is sometimes sub-let to one or two

men, who will take about a hundred feet at a time, and do it entirely by their own labor.

The same work is sometimes done with the wheel-barrow, where two men work to advantage together; they will use two wheel-barrows, one man constantly filling, and the other as constantly wheeling and emptying.

This method, however, is seldom used by a contractor who hires the laborer, for the reason that he can get better results from the use of the plough and scrapers, with which he can do more work and at less cost, and consequently make more profit.

In this work he uses either the dump scraper or the wheel scraper, dump cart or dump wagons according to the distance the material has to be hauled before being dumped.

The dump scraper, or scoop, usually moves about a quarter to a third of a cubic yard of material, according to its size, while the wheel scraper moves from two to three times as much, according to its size, and the dump wagon about one cubic yard at a load; so it is very plain that where a long haul has to be made the teams should

take as large a load as they can carry, so as to diminish the labor and cost of loading and dumping.

The usual method of doing such work is to plough the roadway with a large turning plough, which loosens the earth so that the scrapers can cut into it and fill themselves; or in loading a wagon the shovels can easily cut in, so that the shovellers can handle the earth into the wagons without digging it.

Wherever machinery and horse-power are obtainable, the work can be done in less time and at less cost than by hand labor.

Another type of road machinery now in common use is the road grader, of which there are a number of makes on the market. Their blades are so arranged and so inclined as to cut obliquely at the outer edge, thus making the drain ditch and uniformly sloping the earth to the middle of the roadway, causing the desired "crowning" effect, so necessary for maintenance and drainage. There are also several patterns of road graders and drags combined, which are in common use on light work, where the grading amounts practically to shaping and finishing the roadway and ditches.

Besides these there are also large expensive types of machinery for excavating and moving earth, such as the ditcher, and the steam shovel, which are used in places where continuously heavy cuts and fills will warrant it, but are not in common use as road machinery.

The last, but by no means the least, important feature of good road construction, is the rolling of the entire roadway, whether it is an earth, gravel, or rock road.

The roller usually best adapted to road work is the ten-ton steam roller, which runs as readily backwards as forwards, thus saving time and the disintegration and crumbling of the surface by turning.

There is no special rule for rolling a road, except to roll it until its surface is so compact and firm that it ceases to yield in the least degree under the pressure of the roller.

In rock and gravel roads, it is important to wet the rock as it is being rolled, but this wetting process is not always practicable, and very often an opportune rain will do the wetting at no cost.

On earth roads rolling is as necessary as on rock and gravel roads. The earth is composed of small particles,

and between these particles the magnifying glass reveals open spaces or voids. Through these open spaces moisture collects and even trickles through into the subgrade, making soft, wet places that become mudholes, as soon as reached by the wheel ruts.

It is therefore actually necessary to so roll the roadway and compact it, that these voids are mashed together and filled, so that the water will run off instead of through them.

Always begin rolling at the sides of the road, and roll systematically toward the middle.

Rollers, like other road tools and machinery, are of many makes and patterns; and only scientific knowledge and experience teach the engineer or contractor which is best for his purpose.

QUESTIONS

1. What should promptly follow the staking out of the work?
Ans. The actual construction of the road.

2. Why is this important?
Ans. Because the longer the stakes are left unused, the greater the chance of their being disturbed.

3. What would this cause?

Ans. The tedious task of restaking the work.

4. What is meant by "construction"?

Ans. The actual performance of the physical work.

5. What do you mean by physical work?

Ans. The actual removing of the earth, or other material, in making cuts and fills, as called for by the figures on the stakes.

6. What else?

Ans. The shaping of the roadway in conformity with the cross-section at that point.

7. What else must be followed in this detail?

Ans. It must be done in accordance with the specifications.

8. Does "construction" refer only to the removing of earth and other materials?

Ans. No; it refers also to the mechanical structures.

9. What do you mean by mechanical structures?

Ans. Bridges, culverts, dams, retaining walls, etc.

10. What is a very important feature to be watched in all construction?

Ans. Cost.

11. If done by contract, how can this affect the tax-payer, who pays for it?

Ans. Because the contractor's bid is based on what he estimates the cost to be; and if he has not practised economy of time and labor in making that estimate, the tax-payer is the loser.

12. What do you mean by economy of time and labor?

Ans. So arranging the plan of the work that every yard of material can be moved in the shortest possible time and at the least possible cost of labor.

13. In organizing the out-fits of men and teams what should be kept in view?

Ans. The constant moving of men and teams, so that no idle time of man or team will be paid for.

14. In a scraper or wagon run, if you see one team always stopping for another to get out of the way, what is the cause, and what is the remedy?

Ans. The cause is more teams in the run than the scraper-filler and dumper can handle; the remedy is to remove one team.

15. What, if the scraper-filler is constantly idle?

Ans. Too few teams; one more team should be put in the run.

16. What would you term this?

Ans. The strictest economy of labor.

17. How does this affect a contractor?

Ans. Economy of labor and energy is the secret of success of all successful contractors.

18. What things are embraced by the term "construction"?

Ans. It is very broad in its fullest meaning, and may embrace everything, from "location" to the actual building of the road.

19. What do you know of the modes of construction and the tools and machinery?

Ans. There are various methods of doing the work, and many kinds of tools and machinery with which to do it.

20. How does a contractor know which method to pursue, and which tools to use?

Ans. By scientific study and experience.

21. Suppose a contractor uses wrong tools; for instance, expensive tools to do low-priced work, what follows?

Ans. Failure.

22. What are some of the simplest tools?

Ans. The pick, the spade, the shovel, and the wheel-barrow.

23. What next?

Ans. The plough and scrapers.

24. Are there more than one kind of scraper?

Ans. Yes, there are several kinds; principally the scoop or dump scraper, and the wheel scraper.

25. Name other tools and machinery used in earth-work.

Ans. The dump cart and dump wagon, dump tram-car, steam shovel, etc.

26. Name some other road tools?

Ans. The road grader and the drag, and the grader and drag combined.

27. What other types of excavating machinery are used, and when?

Ans. Ditching machines and steam shovel, but only on continuously heavy work.

28. What is the last step in good road construction?

Ans. Rolling the surface with a heavy road-roller, until it ceases to yield to the pressure of the ten-ton steam roller.

29. Explain the necessity for this on earth roads?

Ans. Earth is formed of small particles; between the particles are open spaces in which water collects and trickles through to the soil below, making soft, wet places that soon become mud-holes.

30. What should the rolling do?

Ans. Close up these open spaces by compacting the earth, so that the water runs off instead of into the road-bed.

31. Where should the rolling commence?

Ans. Begin rolling at the sides, and roll systematically toward the middle of the road.

CHAPTER XII

ROAD MAINTENANCE

THE maintenance of a road embraces its repairs and keeping up. The true meaning of "maintenance" in this place is "preservation."

To maintain a road, therefore, means to preserve it in the condition in which it was built; and the proper way to do that is to repair every damage as fast as it occurs, allowing as little opportunity as possible for time, with its rains, washes, travel, and wear and tear, to increase the growing injury; for with each increase comes also additional cost of repairs, until probably the repairs amount to rebuilding the affected parts.

This preservation does not only refer to the road-bed but to the entire system of physical conditions and mechanical structures.

Usually the most neglected item, and that which should have the promptest attention, is the drain ditches.

They should be cleaned out, if necessary and prac-

ticable, after every rain, for while the road overseer is asleep the ravages of the rains do the most damage. If a ditch is stopped up anywhere the water begins to cut under and around it at once, and can accomplish more damage in an hour than a man can repair in a day, and oftentimes in a week.

So we may readily see the importance of keeping the drain ditches open. When they are stopped up and hold water the benefits derived from the crowning surface of the road-bed are destroyed, as the sub-grade soon becomes saturated with moisture, resulting in deep-cut ruts and mudholes. Mudholes are a great detriment to good roads; and they most persistently occur and recur, not only in earth roads but even in rock roads, only to be filled and filled and filled. One reason for this is that it is so hard to make the average road workman treat the mudhole properly.

As a general rule, a mudhole should be filled with the same material of which the road is built. If a clay road, then with clay; if a sandy clay soil, then with the same sandy clay, and so on. If it is a rock road, fill the mudhole with rock; but never fill it with rock in

an earth road, for you soon have two mudholes with a jolting rock ridge between them.

The proper treatment of a mudhole is first to clean it out: remove the mud entirely off the roadway; even dig it out to the new earth, and scarify the bottom, if necessary. Then fill it with the same material the road-bed is made of, packing it a layer at a time, until it is compact and firm, leaving it slightly higher than the old surface. By the time this slight raise is worn off, or packed in, the wheels will have lost the old mudhole and must make a new one or do without. No highway engineer will question this treatment, but some road overseers may.

Other most necessary conformations to be preserved are the crown of the road-bed, and the slope of the berms, which draw the water from the road-bed to the ditches.

It has been said that a good road is one with a tight roof and a dry cellar, and unless we keep the roof — the crown of the road-bed — tight, so that it will shed the water to the ditches, we can not keep the cellar — the

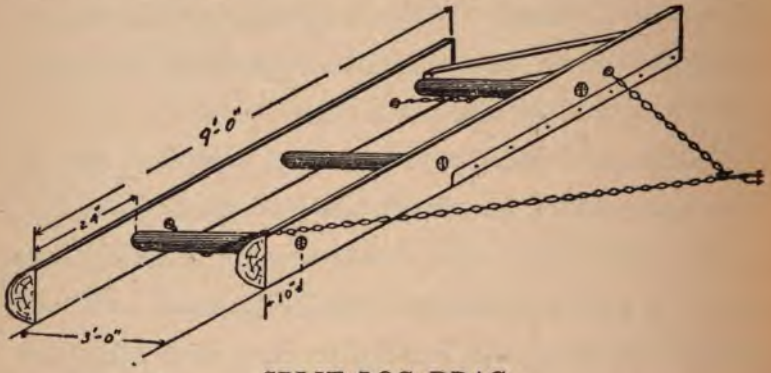
sub-surface — dry. Both must be accomplished, or we shall not have a good road.

This crowning can be done by the use of the grader; but a cheaper and equally suitable tool has been provided by the genius of man for that purpose. This road tool is commonly known as the drag, an illustration of which at work we give. The drag has been tried and adopted in so many States, that various patterns and improvements on the old original "split-log" drag have been placed on the market.

It must not be supposed, however, that we introduce the drag as a new implement; as far back as 1853, Gillespie's "Road and Rail Roads" refers to and recommends the use of the drag in repairing roads. He does not call it a drag, but he says: "A very good substitute for the scraper, in levelling the surface, clearing it of stones, and filling up ruts, consists of a stick of timber, shod with iron, and attached to its tongue, or neap, obliquely, so that it is drawn over the road 'quartering,' and throws all obstructions to one side. The stick may be six feet long, a half-foot wide, and six

inches thick, and have secured to its front side a bar of iron descending half an inch below the wood." Over sixty years ago it was used on the old "Boons Lick" road in Howard County, Mo., and the old drag could still be seen on the side of the road a few years ago.

The drag should be used as soon after every rain as conditions will permit; it is dragged over the road sev-



SPLIT LOG DRAG

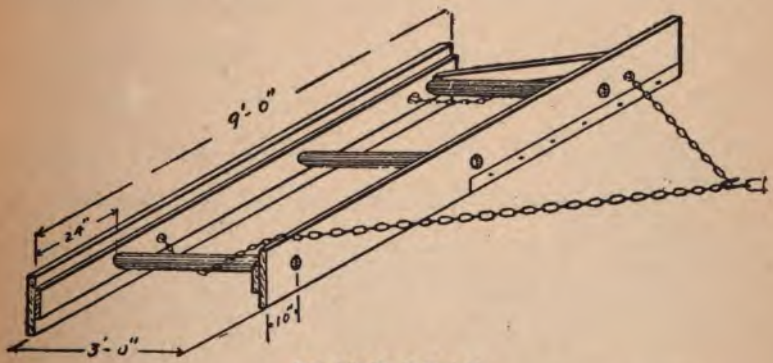
This drag is made from a ten or twelve-inch log, eight or nine feet long. The cross braces are four-inch sticks shaped to fit into a two-inch hole. A board platform, not shown in the cut, is laid on the cross pieces for the driver to stand on.

eral times, filling the newly cut ruts and packing fresh earth into them until the ruts are filled up and packed before they are cut very deep.

This is one of the most inexpensive and easily handled

road tools ever used, and is a blessing to the good road efforts of the day. It has been estimated that a mile of ordinary earth road can be dragged in two hours, so that with teams at two and a half dollars per day, roads should be dragged at twenty-five cents per mile each time.

While the old "split-log" drag was the pioneer drag, the manufacturers of road machinery already have a number of steel drags on the market at reasonable prices, and to-day they are found on every road-side over the entire United States.



PLANK DRAG

This drag is made from two pieces of ten to twelve-inch plank, two or three inches thick and eight or nine feet long, reinforced by a two-inch by six-inch strip. The cross braces are four-inch sticks shaped to fit a two-inch hole. A board platform, not shown in the cut, is laid on the cross pieces for the driver to stand on.

There is also another plank drag known as the "lap plank drag"; it is similar to that used by farmers for smoothing fields after ploughing. Any of these drags can be home-made at a cost of about three to five dollars, and can be used by any boy who can stand on it and drive two mules.

Another system of road preservation that is being adopted in many States is the oiling process, used not only as a preservative but as a dust preventive. The oil fills and waterproofs the top surface of the roadway, thereby preventing the water from permeating and soaking the road-bed, and thus partially preventing ruts and mudholes. Again, the surface being covered with oil, the erosions from the wear and tear of traffic form a sticky paste which remains mostly on the roadway, instead of a fine dust which blows off or washes away.

The oiling is by no means permanent, as it is necessary to oil a roadway from one to three times a year, according to the travel over it and the amount of oil used per square yard. Oil is applied in varying quantities from one-quarter to one and one-quarter gallons per square yard, and at a cost of from three and a-half cents

A FINE IMPROVED EARTH ROAD AT McMINNVILLE, OREGON

SHOWING HOW THE USE OF A HOME-MADE DRAG BRINGS CHURCH AND SCHOOL NEARER TO THE PEOPLE. ROAD COMMISSIONER OHLENDORF IS DRIVING THE DRAG

A ROAD CADET PATROL

to eight or more cents per gallon, so that the cost per mile is a variable quantity, running from one cent per square yard to ten cents or more per square yard.

Oil is applied either by the mixing or the penetrating process; that is, mixed in with the road material, or poured or sprinkled over it and allowed to soak into it.

Another feature of road maintenance, largely practised in European countries, and now being urged by road builders in this country, especially by the Good Roads Department of the National Congress of Mothers, is the patrol system. Napoleon made the magnificent highways of France world-famous by his military patrol of her roads;— why should we not follow his noble example and profit by it? By the patrol system is meant the constant care and watching of a roadway by an organized force of properly equipped men, whose duty it is to watch the road-bed, ditches, water-ways, and mechanical structures, and to repair defects or damages as fast as they occur from the effects of weather or traffic.

The National Congress of Mothers is organizing Road-Cadet Patrols all over the country, the object of

which is to familiarize and train the boy of to-day — the man of to-morrow — in the various features of road inspection and maintenance. For this purpose they propose to have regularly organized and officered road cadets in every school district in the entire country.

These road cadets are to be furnished with a blank, called a "questionaire" or "log," asking questions regarding road-maintenance, such as the kind of road, nature of construction, its use to the community, grade per cent, if properly drained, properly crowned, properly worked by road overseer, and such other questions as would practise the observation and road-building knowledge of a boy.

These questions are answered by a squad of road cadets going over and studying the conditions of a certain mileage of roadway near their school-house and reporting on same, prizes or recognition of some sort being offered for the best log.

QUESTIONS

1. What does "maintenance" mean in reference to a road?
Ans. The repairing and keeping up of a road.

2. What do you mean by repairing and keeping up?

Ans. The preservation of the roadway in the condition in which it was built.

3. Is it important that damages be repaired promptly? and why?

Ans. Yes; because time, and the bad effects of rains, washes, and the wear and tear of travel, add constantly to the cost of repairs until checked.

4. Does this preservation refer only to the road-bed?

Ans. No; it refers to all physical work, such as road-beds, berms, and ditches.

5. What else?

Ans. Also to mechanical structures, such as bridges, culverts, and walls.

6. What is the first thing that should be watched by road overseers?

Ans. The drain ditches.

7. Why?

Ans. Because as soon as one is stopped up, the rain water begins to cut under and around it, causing in an hour more damage than a man can repair in a day.

8. What else?

Ans. If the water stops running off it fills the ditches; then softens the road-bed and berms, so that deep ruts are cut and mudholes are made.

9. How should this be remedied?

Ans. The ditches should be opened, where necessary, after every rain.

10. What is another problem in road maintenance?

Ans. Mudholes; their constant occurrence and recurrence.

11. Why do mudholes occur and recur?

Ans. They are first caused by moisture softening the road-bed; and they recur from improper filling.

12. How should mudholes be filled?

Ans. They should first be thoroughly cleaned out, and the mud should be removed off the roadway.

13. What next?

Ans. Fill the dry hole with the same material the road-bed is built with, packing it, a layer at a time, leaving it slightly higher than the surface.

14. Does this apply only to earth roads?

Ans. No; to all classes of roads; if it is a rock road fill it with rock, after first digging out the hole.

15. What other conformations are to be preserved in road maintenance?

Ans. The crowned road-bed and the slope of the berms toward the drain ditches.

16. Why?

Ans. To shed the water off the crowned surface and over the sloping berms to the ditches.

17. Name two necessary things in a good road.

Ans. "A tight roof and a dry cellar."

18. What is the roof of the road?

Ans. The rounding crown over the road-bed.

19. What is the cellar?

Ans. The sub-surface or earth under the road-bed.

20. What simple road tool has been especially and persistently urged for road preservation?

Ans. The "split-log" drag.

21. How is the drag used?

Ans. The cutting and dragging blades are so arranged as to scrape the slopes of the crowned road-bed toward the middle, preserving the crown and filling and packing the newly made ruts with fresh earth.

22. When is the best time to use the drag?

Ans. As soon after rains as the conditions will permit.

23. Is the drag an expensive or intricate road tool?

Ans. No; it is so inexpensive and simple that it is now almost universally used, and can be seen on every road-side over the entire United States.

24. Is the idea of the drag new?

Ans. No; W. M. Gillespie, C.E., recommended its use in his "Roads and Rail Roads," published in 1853.

25. Name another means of road-maintenance used in various States.

Ans. Oiling the surface of road-beds.

26. What other purpose does the oiling serve?

Ans. It is a dust preventive.

27. How does oil preserve a road-bed?

Ans. The oil fills and waterproofs the top surface, and partially prevents rains soaking in and causing ruts and mudholes.

28. What is its effect on dust?

Ans. The erosions from travel become a sticky paste and stay on the road-bed instead of forming dust to be blown off or washed away.

29. Is oiling in any sense permanent?

Ans. No; it is temporary, and has to be repeated one or more times a year, according to the amount used and the traffic over the road.

30. How is oil applied?

Ans. Either by the mixing or the penetration method.

31. Name another system of road maintenance.

Ans. The patrol system.

32. What is the patrol system?

Ans. The constant watching of a road, repairing defects and damages as fast as they occur.

33. By whom is the patrol system urged in this country?

Ans. By all good road builders, but especially by the Good Roads Department of the National Congress of Mothers.

34. Through what means are they urging it?

Ans. The Road Cadet Patrol, an organized body of boys in school districts, whose aim is to study road-work, visit the roads and systematically report their condition on blanks furnished for the purpose.

35. What are these blank reports called?

Ans. "Questionaires" or "logs."

36. To whom are these logs reported?

Ans. The Patrol officer, School Superintendent, County Court, or County Highway Engineer.

CHAPTER XIII

WIDE AND NARROW TIRES — HIGH AND LOW WHEELS

TOGETHER with the ill effects of poor drainage and the consequent evil results of a softened road-bed and berms, the wear and tear of travel in wheeled vehicles is unceasingly at work. The wheels first cut the ruts, which hold moisture and soften the road-bed, until ruts become miniature drains down the roadway, taking the water down the road-bed instead of diverting it to the side drain-ditches.

Next to the disastrous cutting by heavy rain-falls, comes the constant cutting by the narrow tires of heavily loaded wagons and carriages. Tires are a necessity, but many States and foreign countries have decided that *narrow* tires are not, and have laws regulating the widths of tires permitted on wagons of certain capacities of haul.

It is too evident to be discussed, that a narrow tire with a heavy load on it, will cut deeper into soft, moist earth than a much wider tire. In fact, if the wide tire is three or four inches wide, or wider, it becomes a minia-

ture roller, and actually benefits the road instead of damaging it.

The wheels of buggies and wagons are supposed to "track"; that is, the hind wheel follows directly in the track of the front, and if the front tire cuts into the road-bed, then the hind tire will cut a little deeper; and so the damage is continued day after day. The simplest and most beneficial remedy for this is the use of wide tires in the place of narrow, the wide tires packing the road instead of cutting it.

Another remedy, though not always approved, is the building of heavy-traffic vehicles so that the hind wheel will never track the front.

In France, they not only have very broad tires, varying from three to ten inches,— usually four to six inches, according to the tonnage of the wagon,— but they have the rear axle fourteen inches longer than the front, so that the two wheels never track each other, and their heavy wagons actually compact the surface instead of cutting it.

To show the importance of this feature of traffic and its effect on roads and capacity of haul, we will briefly

cite some figures taken from consular reports, and from experiments by foreign governments.

First as to haul: The comparative loads that can be hauled with the same energy on a one-inch or narrow tire, and a three-inch tire, are as follows: on macadam roads, 2,500 pounds as against 2,000 pounds; on gravel roads, 2,482 pounds as against 2,000 pounds; on dry earth roads, 2,500 pounds as against 2,000 pounds; and on clay roads, with deep mud, slightly dry on top, tests showed an average of 3,200 pounds as against 2,000 pounds.

In the United States a number of States have laws regulating the width of tires.

In Europe the strictest attention is paid to it and it has been made the subject of reports to our Government by some of our foreign consuls.

In Austria, two-and-a-quarter-ton wagons must have four-and-a-third-inch tires; and if built for more than four and a half tons they are compelled to have six-and-a-quarter-inch tires. In Germany, all heavy draft wagons have four-inch tires, as a protection to their

WAGON EQUIPPED WITH SIX-INCH TIRES AND LOW WHEELS

WAGON WITH SIX-INCH TIRES AND MEDIUM WHEELS.— 9.5 PER CENT LIGHTER PULL THAN ON LOW WHEELS

WAGON WITH SIX-INCH TIRES AND STANDARD WHEELS,— MUCH LIGHTER PULL THAN ON MEDIUM OR LOW WHEELS, BY ACTUAL EXPERIMENT

PREPARING SUB-GRADE FOR MACADAM ROAD; TRACTION ENGINE DRAWING ROAD MACHINE

highly improved roads. In fact, in Europe narrow tires have long since been practically discontinued.

It must be remembered, however, that narrow tires and wide tires will never work together, especially on earth roads, as the narrow tires would cut the mud so that the wide tires would take it up, instead of packing and compacting it. But, if the narrow tire were prohibited, the wide tire would always roll and compact the road.

Another influence on the draft of wagons is the use of high and low wheels; but this need not be discussed here further than to state that the standard high-wheeled wagons are of lighter draft than low-wheeled.

QUESTIONS

1. What is one of the principal causes of damage to roadways?

Ans. The wear and tear by wheeled vehicles.

2. How do the wheeled vehicles affect the road?

Ans. The tires cut ruts in soft places and the ruts drain the water down the road-bed instead of diverting it into the side ditches.

3. Do all wheeled vehicles cut alike?

Ans. No; the heavily loaded wagons on narrow tires do the most damage.

4. How is this cutting of the ruts intensified?

Ans. By the hind wheel running directly in the track of the front, cutting the ruts deeper and deeper each trip over the road.

5. How can this evil be lessened?

Ans. By substituting wide tires for narrow tires.

6. How else?

Ans. By making the hind axle of broad-tired wagons longer than the front, so that each wheel will run in a different place.

7. What would be the effect of this?

Ans. Each wheel would become a miniature roller, and the wagon traffic would become a benefit instead of a detriment to the road.

8. Are tires a necessity?

Ans. Yes; but narrow tires are not.

9. Are tire widths regulated by law in any country?

Ans. Yes; in a number of the States in the United States, and in nearly all European countries.

10. How is this done?

Ans. By passing laws compelling certain widths of tires for certain tonnage of wagons.

11. How does the width of the tires affect the hauling capacity of the wagon?

Ans. A team, with the same energy, can haul a greater load on a wide-tired wagon than on narrow tires.

12. Will narrow tires and wide tires work to advantage on the same road?

Ans. No; the narrow tire will cut up the mud, so that the wide tire will pick it up instead of rolling and compacting it.

13. How does the high wheel influence the draft of wagons?

Ans. The standard high-wheeled wagons are of lighter draft than the low-wheeled.

CHAPTER XIV

EARTH AND WOODEN ROADS

THE term "road" includes every avenue of travel, from the trail of our pioneer forefathers to the highway of the auto-riding rich of to-day. The many types of roads vary in material and structure almost as much as the fabric and texture of the clothing that we wear in the several seasons of the year. There are so many different characters of roads that we will not attempt a detailed description of each kind, but will briefly discuss a few of the most commonly used, grouping them in classes, to cover the various wearing surfaces that have been adopted as most practicable and most suitable to the wear and tear of travel and the cost of construction and maintenance, with the limited local facilities.

The most universally used roads are the common country roads, and we will group in that class such improvements as our country communities have been able to construct in the past.

There are two kinds of roads that, like the poor, we always have with us,— the good and the bad; and it is to rid the country of the latter and firmly and permanently establish the former, that is the prime object of this book.

We will first call brief attention to earth roads, grouping with them all those roads that attempt a hard, artificial wearing surface other than rock, brick, or concrete, and known commonly as pike, plank, corduroy, or wooden roads,— such roads as need no scientific preparation of the sub-grade before the short-lived wearing surface is placed on it to lift the heavy traffic over treacherous places.

Earth roads, unimproved by art, are very deficient at all times in the important requisite of smooth and hard surfaces, and in frequent instances would become impassable unless the surface were provided with some artificial covering to lift the traffic over the soft places.

Another remedy for such places is the thorough drainage by ditches on both sides of the road, and the narrowing of it to such a width as will reduce the

maintenance to the minimum cost, and yet accommodate the travel.

The illustration opposite shows an earth road that was much wider than the travel demanded, necessitating unnecessary expense to keep it in repair. To lessen the cost of construction of a permanent highway, as well as its future maintenance, the actual road-bed was reduced to fifteen feet, leaving an earth berm on each side.

Study the travelled portion of a roadway, and it will usually suggest to you the width demanded by the traffic of the community.

Many communities, in every part of this country, must put up with the earth road — it is a part of the physical condition of our country,— but all such should be graded, crowned, and drained, and thus made good roads instead of bad roads,— that curse of our country.

It should be remembered that the improvement of the local highways is the improvement of the farmers' personal property,— the road to his farm, his gate, his yard, his home, his fireside, where he and his wife and his children enjoy the real comforts and blessings of life; life that may be made as enjoyable and profitable in

THIS EARTH ROAD WAS MUCH WIDER THAN THE TRAVEL DEMANDED. TO LESSEN THE EXPENSE, THE ROAD-BED WAS REDUCED TO FIFTEEN FEET, LEAVING AN EARTH BERM ON EACH SIDE

THIS GRAVEL ROAD WASHED BADLY BECAUSE IT WAS NOT CROWNED WHEN BUILT

THE SAME ROAD WAS CROWNED SIMPLY BY THE JUDICIOUS USE OF A DRAG

the country as in the city, if the environments and conditions for such are encouraged and paid for. Remember, "home is the resort of love, of joy, of peace and plenty," but it will be of no avail, if, through the home-maker's close-fisted parsimony, his friends and neighbors can reach him only through mud and slush.

The pictures adjacent are good illustrations of the improvement of an old earth road that was simply improved by grading and crowning. Earth roads, therefore, should be graded and drained, if not otherwise improved. Remember, earth roads *wash out* more than they *wear out,* and if you will arrest the wash before it does any damage, the road will never wear out.

Before leaving the subject of earth roads, it is only necessary to remind the reader that there are many kinds of earth, some much more suitable for roads than others; sometimes a road is too clayey, and sometimes too sandy. In such instances the material of the wearing surface is changed for the better by mixing the two earth elements together, such as adding sand to a sticky clay road, or adding clay, or even oil, to a too sandy road.

The accompanying illustrations show the method of adding sand to a clay road, after which the drag and roller complete the job.

These two illustrations speak for themselves, as striking evidences of the method of constructing and improving good earth roads, and of the paying result in service and comfort of travel.

Even before the days of road-rollers, or drags and graders, the necessity existed for covering the surfaces of road-beds in soft, spongy places with some harder material, and we had what may be termed the age of wooden roads, as we are to-day in the age of rock and concrete.

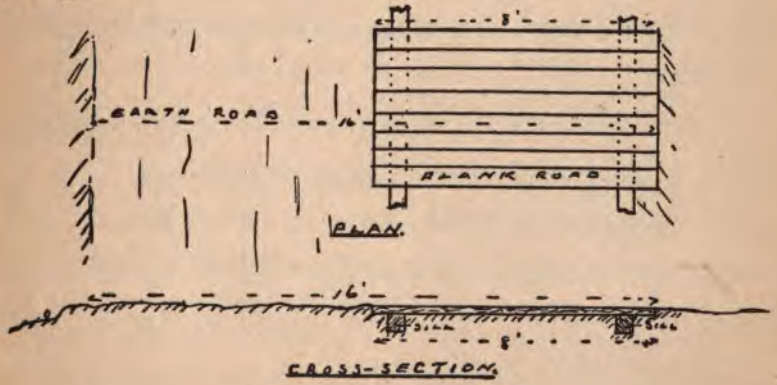
These wooden roads embraced the corduroy, pike, and plank roads, and a few others, and will receive only a cursory notice.

The corduroy road is constructed by felling straight young trees, as even and uniform in size as possible, laying them side by side, and as close as possible together, across the roadway, at right angles to its length. This is merely a make-shift for a road, and is never recommended either for durability or ease of travel. Next

MIXING SAND AND CLAY AT HALLSVILLE, TEXAS, WITH TRACTION ENGINE AND PLOUGH

MIXING SAND AND CLAY AT QUINCY, FLORIDA, WITH THE DISC-CUTTER

came the charcoal road, which was made by burning green timber along the roadway and covering the road-bed with the charcoal thus obtained. The charcoal was prepared by piling the green timber in stacks on end along the middle of the roadway, covering it with earth and then firing it. The earth for covering it was taken out of the middle of the road. When the wood was charred, the earth was banked on each side of the road-bed forming a berm, and the charcoal was spread in the trough thus made down the middle of the roadway. It was then distributed over this fifteen-foot road-bed two feet thick in the middle and one foot thick on each side. Even for the old charcoal road they prepared a sub-grade.



OLD PLANK ROAD

Next came the plank road. This was usually built on one side of the roadway and generally on the right hand side approaching the town.

Sleepers, usually of planks four inches thick, were laid lengthwise of the road. On these were laid other planks, three inches thick and from nine to twelve inches wide, at right angles to the length of the road. These roads were moderate in cost, easy in travel, but of short vitality.

These are the roads that are usually referred to as "pikes" or "turnpikes," the term being taken from the custom of having turnpikes or turnstiles at certain places on the road, which were turned open for passage over the roads on the payment of a certain toll allowed by law for using it, and which was spent for the maintenance of the road.

Later, however, the same turnstiles were established on rock and shell roads for the same purposes.

A turnpike is a frame consisting of two bars crossing each other at right angles and turning on a post to prevent the passage of vehicles or animals over a road until opened by the toll-gate keeper.

After plank roads should come wood-paved roads,—that is, roads paved with wooden hexagon or oblong blocks, laid as brick, but it comes so nearly to exclusive city use, that we will pass it with simply a reference to show its sequence in wooden road-coverings.

The connecting link between the wooden and the "metal-surfaced" road should be the cinder path or road, as that may be either from wood or coal, or mineral product, but this reference is notice sufficient.

QUESTIONS

1. What is the most commonly used road?

Ans. The earth road, or common country road.

2. What two kinds of roads do we always have with us?

Ans. The good and the bad.

3. What is the prime reason for all road work?

Ans. To rid the country of the bad roads and permanently establish the good.

4. What class of roads followed the common earth roads?

Ans. Wooden roads, such as the corduroy, the charcoal road, and the plank or turnpike road.

5. How is a corduroy road made?

Ans. By cutting young trees of uniform thickness and length, and laying them across the road as close together as possible.

6. What is a charcoal road?

Ans. A charcoal road is made by cutting timber and burning it along the middle of the roadway, then distributing the charcoal thus made two feet thick in the middle and one foot thick on each side of the road-bed.

7. How was this charcoal burnt?

Ans. The green timber was piled on end along the middle of the roadway, covered with earth and then fired until charred.

8. What followed the charcoal road?

Ans. The plank road.

9. How are plank roads built?

Ans. By laying sleepers lengthwise of the road, and laying heavy plank across the sleepers at right angles to the road and close up together.

10. What is the difference, if any, between the plank and the turnpike road?

Ans. There is none; the turnpike takes its name from a turnpike or turnstile built across the road, travellers being charged toll for using the road, before the turnstile was opened.

11. Describe a turnstile.

Ans. A turnpike or turnstile is a frame consisting of two bars crossing each other at right angles and turning on a post to prevent anything passing until it is opened.

12. For what purpose was this toll used?

Ans. To defray the expense of keeping the road in repair.

13. What is the next wooden roadway?

Ans. Roads paved with wooden blocks, usually in city streets.

CHAPTER XV

METAL-SURFACED ROADS — GRAVEL — ROCK — BRICK — CONCRETE

THE term "metal" is used by engineers to denote any hard material, such as broken stone, to form the surface of highly improved roads, and may refer to either gravel, rock, brick, or concrete.

Stone tramways are the pioneers in rock roads, and are supposed to have been used by the Egyptians as far back as the days of the Pyramids, the huge stones in them having been, it is said, moved over stone tracks. Stone tramways are formed by laying two parallel lines of long flat stone blocks, the proper width apart for the wheels to run on, with a pavement of gravel or pebbles between for the horses to travel on. They are practically things of the past, and are referred to only as an instance of the antiquity of rock roads.

In the chain of rock-road succession the next link is the gravel road; it is still used, and much cheaper than

rock roads, where the gravel for its construction is at hand.

The sub-grade for gravel, and all other permanently improved roads, must be specially prepared and *rolled* for the reception of the wearing metal surface. That is, for the width of the proposed road-bed a trough must be cut out as deep at the outer edges as the surface material on the edges of the road-bed is specified in thickness, and so crowned, or curved, across its width that when the required depth of stone in the middle is laid and rolled, the cross-section of the top of the road-bed will be in accordance with the prescribed conformation of the finished road, thus:

CONSTRUCTION OF A ROCK ROAD

AN OLD STONE TRAMWAY IN NEW YORK, BUILT EIGHTY YEARS AGO

FORCE OF MEN WORKING TO REDUCE A HILL AT BOONVILLE, MISSOURI, FROM A 13 TO A 7 PER CENT GRADE. THIS SHOWS THE USE OF PLOUGHS AND WHEEL AND DUMP SCRAPERS. THE ENGINEER IS SHOWING A DUMP SCRAPER TO C. A. SOMBART, THE COMMISSIONER

BUILDING AN EARTH ROAD WITH REVERSIBLE ROAD MACHINE AT GREENVILLE, MISSISSIPPI

This illustration will serve for all metal roads of whatever class.

Not deeming the old cobble-stone roads of our forefathers worthy of serious notice, the next in cheapness of construction that we will note are the shale roads and the shell roads. The former are used only where quarries of shale are to be found; the shell roads are used around our coast cities, where huge mountains of oyster shells are to be had at slight cost.

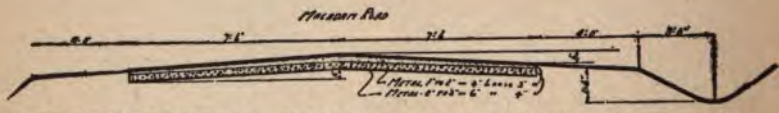
Shell roads, however, do not stand the rough usage of modern traffic and are seldom built in this age.

This brings us to the ordinary rock road, known by various names. The Macadam and Telford roads being the two principal types, a brief description of each will answer the purposes of this elementary book.

These types of rock roads take their names from the surnames of the road builders who first advocated their adoption. The Macadam road, using small broken stone for the entire thickness of the wearing surface, was first advocated by Sir John L. Macadam, who was born in 1756; whence comes the term "macadam-

ize," meaning to cover the road-bed with broken stones as advocated by him. This covering is put on in layers of stone broken to certain prescribed sizes, each layer being wetted and rolled or rammed so as to bind them together until they will resist the cutting of the wheels and the wear and tear of such travel and traffic as the road is to be used for.

The specifications for the thickness of Macadam roads, and for the sizes of the stones, and for the amount of rolling, vary according to the uses to which the road-bed will be subjected, and as dictated by the judgment and experience of the engineer.



CROSS-SECTION, SHOWING DETAIL OF MACADAM ROAD

Thomas Telford was a Scotchman, and a civil engineer of such vast experience and unlimited professional resources, that his ideas still command the attention of the world, as do those of John L. Macadam, another Scotchman. He did his greatest work in the latter part

MACADAM ROAD IN MISSOURI WHICH SHOWS THE EFFECTS OF A POOR SUB-GRADE AND NO ROLLING

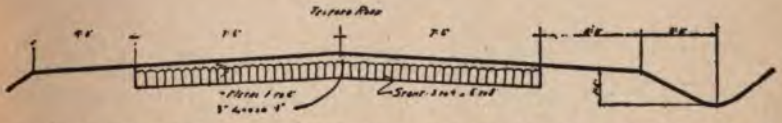
A WELL CONSTRUCTED MACADAM ROAD

ROCK-CRUSHING PLANT, ATLANTA, GEORGIA, SHOWING TRAIN BEING LOADED, AND CAR FROM QUARRY ABOUT TO DUMP

of the eighteenth and the early part of the nineteenth century, almost contemporary with that of Mr. Macadam.

The only real difference between the Macadam road and the Telford road, is the use by the latter of foundation stones of larger size in the bottom of the sub-grade, stones say from four to eight inches in width, eight to fourteen inches long and not less than eight inches deep, placed by hand across the roadway, with the interstices filled with "spauls" or small stone chippings rammed in.

The original Telford specifications called for a binding course on top consisting of an inch and a half of good gravel, free from clay or earth.



CROSS-SECTION, SHOWING DETAIL OF TELFORD ROCK ROAD

Engineers still differ as to which is the better — the Macadam or the Telford road. The probable fact is, that the soil conditions and the nature of the surrounding rock have largely to do with the question, and prob-

ably no fixed rule will govern all localities as to which is more practicable and desirable.

To finish either in perfection, the use of some bituminous, asphalt, or tar compound or oil, is advisable, to bind the rock, shed the water, and lay the dust; but as this is not always possible, and many patent fillers are on the market, the point is beyond the scope of this elementary work.

The brick-paved road-bed should next be considered, but as it is confined almost exclusively to city streets, we will simply treat it by illustration and a very brief description.

The sub-grade is prepared and convexed or crowned as carefully as for any other improved road-bed. A cushion of sand, about four inches thick is then carefully spread on this sub-grade; on this cushion a layer of ordinary brick is laid flat and lengthwise with the road-bed from shoulder to shoulder, or curb to curb. On this is spread a two-inch cushion of sand, for filling in between the bricks and giving a uniform bearing for the wearing course. This course is always of a hard vitrified brick, laid on edge and lengthwise across the road-bed, with

5-INCH CONCRETE PAVEMENT AND 8-INCH CURB FOR BRICK PAVEMENT AS USED IN NEW YORK HIGHWAY WORK

SHAPING AND ROLLING OF 2-INCH SAND CUSHION OVER FOUNDATION

LAYING BRICK ON SAND CUSHION

ROLLING AND INSPECTING BRICK

joints broken, and on which a filling layer of sand is spread one inch thick, and left until it goes into the joints. Many patent fillers are also used for this purpose.

When the foundation demands it, a four-inch foundation course of concrete may be substituted for the first layer of brick.

Like the brick-paved road-bed, the concrete and asphalt road-beds are so largely used in cities, that only a passing notice and description will be given them here, as this elementary book for boys and girls does not contemplate going into the details of city streets and pavements.

The sub-grade for the concrete and asphalt pavement is prepared exactly as for the brick, except as to depth, which is always governed by the prescribed depth of material used.

Concrete is a mixture of cement, sand, and stone or gravel, thoroughly manipulated and mixed with water, the proportions of the three constituent parts being fixed by specification according to the uses to which the road-bed will be subjected. This proportioned mixture is

governed by fixed rules, but is left usually to the judgment and experience of the engineer.

The fixed rules specify the amount of cement and sand that it will take to fill the voids in the aggregate, which varies as to the size of the crushed stone. The cement is practically a powder and has no perceptible openings; the microscope, however, will reveal the fact that clean, sharp sand is made up of small cubes, with openings in between, usually termed "voids," and when mixed together the cement is supposed to fill these voids.

Voids exist also in the aggregate or crushed stone, as is evident to the naked eye. The percentage of voids in the whole bulk is according to the sizes of the broken pieces.

Therefore, to make the whole a solid mass, when properly mixed and compacted, the quantity of cement and sand is calculated according to the percentage of voids in the aggregate,— the term used to denote the crushed rock or gravel.

For instance, if you see the formula, a mixture of 1 — 2 — 5, it means, one part cement, two parts clean sharp sand, and five parts of rock or gravel.

FIRST APPLICATION OF THE CEMENT FILLER BEING SWEPT INTO INTERSTICES WITH BROOMS. IF A SAND FILLER IS USED, AS MENTIONED, IT IS LIKEWISE SWEPT IN

SECOND AND FINAL APPLICATION OF THE CEMENT FILLER, THE SURPLUS BEING REMOVED WITH SQUEEGEES TO MAKE A PERFECTLY EVEN SURFACE

A SECTION OF BRICK PAVEMENT IN USE — SLIGHTLY CROWNED

A DANGEROUS CURVE ON A BRICK ROADWAY SLIGHTLY BANKED TO PREVENT SKIDDING

There is also a bituminous concrete, which is simply a concrete mixed with bituminous or asphaltic cement; it needs no further explanation as it is rarely used for common road surfaces.

The use of sheet asphalt pavements is confined almost exclusively to city street-work and will receive only a passing notice as the final result of road-bed building, leading up to the several patent pavements on the market.

Asphalt consists of an asphaltic concrete binder, made of hard durable stone, not over one inch in size, and a hard, moderately sharp, clean sand, mixed with asphaltic cement, which is prepared by a specified formula; the mass is mixed, in suitable appliances, at a prescribed degree of heat, say from 200 to 325 degrees Fahrenheit, the proportion of each ingredient to be prescribed and specified. The concrete thus formed will be a compact mass, containing the very fewest possible "voids."

This is placed upon the sub-grade and raked to a uniform prescribed thickness, after being compacted and rolled. All is done under binding conditions and precautions against poor work or inferior material.

This is then covered, as soon as possible, and under prescribed degrees of heat, with the asphaltic surface-mixture or wearing course, which is composed of soluble bitumen, Portland cement, or stone-dust and sand of certain prescribed quality, as determined and gauged by the wire screen sieves used for that purpose.

This filler is put on while hot, and distributed to the prescribed thickness, after it is rolled, which compacting is kept up until all roller marks disappear and the surface gives no indication of further compressibility.

This completes an asphalt street surface; and also this book, written for the child-mind, and not for the severe criticism of the professional expert.

QUESTIONS

1. What is meant by the term "metal" in reference to road surfaces?

Ans. It is used to denote any of the hard wearing-surfaces.

2. What is the first stone roadway we have any account of?

Ans. The stone tramway.

3. How long have they been used?

Ans. They are said to have been used by the Egyptians for transporting the huge stones in the Pyramids.

4. How were they built?

Ans. By laying two parallel lines of long flat stone blocks for the wheels to run on.

5. What was between these two lines of stones?

Ans. A pavement of gravel or pebbles for the horses to walk on.

6. Are they ever built now?

Ans. No; but some are still in existence that were built nearly a century ago.

7. What is the next road with metal surface?

Ans. The gravel road.

8. Are gravel and rock roads built on the surface of the roadway?

Ans. No; a sub-grade is always prepared and rolled for the reception of the gravel, rock, or concrete.

9. How?

Ans. A trough is dug lengthwise of the road and across its full width, so that the form of the bottom of the trough is the same as that which the finished road-bed will be.

10. Give some details.

Ans. It is dug as deep on the edges as the rock is specified to be in thickness, and in the middle so deep that when the prescribed thickness of the rock for the middle is placed and rolled, it will bring the road-bed to the proper crown.

11. Why are cobble-stone roads not considered in this book?

Ans. Because they are very hard on man and horse and vehicle, and never should be built.

12. What roads come next in regard to cheapness of construction?

Ans. The shale road, where a quarry of shale is near, and the shell road, where large deposits of oyster and other sea shells are obtainable at low cost.

13. Name the two types of rock roads most commonly used.

Ans. The Macadam and the Telford.

14. How did these roads get their distinctive names?

Ans. From the names of two noted civil engineers, who first advocated their modes of construction.

15. After whom is the Macadam road named?

Ans. Sir John L. Macadam.

16. Who was he?

Ans. A noted Scotch engineer, born in 1756.

17. What did he advocate?

Ans. A road-bed covered with layers of crushed rock of small size, the smallest size placed on top and thoroughly rolled or rammed as a binder course.

18. From whom does the term "Telford road" take its distinctive name?

Ans. From Thomas Telford, a Scotch engineer of vast experience and professional resources.

19. What is a Telford Road?

Ans. Practically a Macadam road, with this difference, however, that the bottom course is of large flat stones set on edge, across the road-bed, and filled in between with small flat stone clippings.

20. What does the stone mason call stone chippings?

Ans. "Spauls."

21. What is the binder or wearing surface of the Telford road?

Ans. Small crushed stone, topped out with a binding course of gravel, free from clay, and an inch and a half thick.

22. Which of the roads is preferred by engineers?

Ans. They always have differed as to the advantages of the two types.

23. What is likely the case?

Ans. That local conditions of soil and surroundings have largely to do with the choice between the two.

24. To make any rock road virtually perfect, what is necessary?

Ans. A binder or filler of some bituminous, asphaltic, or tar compound.

25. What does this effect?

Ans. It binds the top rock together, sheds the water, and lays the dust.

26. Name another metal-surface road-bed?

Ans. The brick pavement.

27. How are brick pavements laid?

Ans. Usually with two layers of brick, with a sand cushion below, a sand cushion between, and a sand or other filler on top.

28. What kinds of bricks are used?

Ans. Common brick, laid flat, lengthwise of the road, for the first course, supported on a four-inch cushion of sand.

29. What for the second or top course?

Ans. Hard vitrified bricks, laid on edge lengthwise, across the road and supported on a two-inch cushion of sand.

30. What is the benefit of the sand?

Ans. It fills in between the lower bricks and gives a uniform bearing for the top course.

31. How is the top course finished?

Ans. With a one-inch layer of sand, which is left on it until it settles in between the bricks, holding them perfectly tight up against each other.

32. What else does it do?

Ans. Fills the spaces in between the bricks so that the water will run off into the gutter instead of soaking in.

33. What is concrete?

Ans. A mixture of cement, sand, and crushed stone or gravel.

34. How is this mixture determined?

Ans. So that the little voids in the sharp sand will be filled by the powdered cement, and the voids in the crushed rocks by the mixture of cement and sand.

35. What does this form?

Ans. When set, it makes the whole — the cement, sand, and stone or gravel — a solid, rock-like mass.

36. What do you understand by a 1—2—5 mixture?

Ans. A mixture of one part cement, two parts sand, and five parts gravel or rock.

37. What is meant by the term "aggregate"?

Ans. The coarser part, or main body, of the mixture, such as gravel, rock, or cinders.

38. What is bituminous concrete?

Ans. It is a concrete mixed with bituminous or asphaltic cement.

39. What is asphalt?

Ans. Asphalt is a street surface composed of asphaltic concrete binder, made of asphaltic cement, sand, and stone.

40. How is this finished?

Ans. It is covered with the asphaltic surface mixture, or wearing course.

41. Of what is this composed?

Ans. Soluble bitumen, Portland cement or stone dust, and fine sand.

42. How are the asphalt binder and the wearing surface applied?

Ans. Always under prescribed degrees of heat.

43. What is the final treatment?

Ans. Rolling until all roller marks disappear, and there are no further indications of compressibility.

Our Thanks.

I take grateful pleasure in acknowledging the professional courtesies of those from whose road bulletins and magazines I have drawn so heavily for illustrations; and especially to the United States Department of Good Roads at Washington, D. C., for the very valuable photographs sent me for illustrating this little road primer for the child of the field and the foot-hills.

S. W. R.

THEIR ACCEPTANCE.

To The Hon. Samuel W. Ravenel,
Civil Engineer, Boonville, Missouri.

DEAR SIR: In behalf of The National Congress of Mothers, and particularly the "Department of Good Roads for Child Welfare," I desire to express gratitude and thanks to you for granting the request to compile a Road Primer, which would leave an imprint upon the youthful mind — and impress all children with the importance of good roads.

The "Ravenel Road Primer," as submitted for examination, seems to me to be one of the most attractive and at the same time instructive elementary treatises that could be arranged.

Again thanking you for your devotion to the cause of the child, — the best asset of the Nation,— and your intelligent services in its behalf, I remain, with best wishes,

Very respectfully,

MRS. FRANK DEGARMO,
National Chairman,
Good Roads for Child Welfare Department,
National Congress of Mothers.

From Hon. Curtis Hill, State Highway Engineer, Missouri.

"I have gone over the manuscript of your work, 'Ravenel's Road Primer for School Children.' It will be undoubtedly one of the best publications for the purpose ever printed. It covers the subject sufficiently and in a manner to leave the imprint upon the youthful mind.

"Since the public roads so closely affect our commercial conditions and our social and educational environments, there is every reason why the school boy and girl should be impressed with the importance of good roads and be given an understanding of the elementary principles of road administration and construction.

"Your work will fill a much needed course of instruction for which you deserve the thanks of every one interested in the subject — and this should be every man, woman, and child in the state.

"Not only is it adaptable to the school room, but it makes interesting reading for an adult. I would recommend it to our Highway Engineers."

From Col. T. A. Johnston, Sup't Kemper Military School, Boonville, Mo. (After forty years' experience with boys.)

"I have examined with a good deal of interest the manuscript of the 'Ravenel Road Primer.' It is an excellent summary of the principles and a clear explanation of the processes and terms used in road making. It appears to be specially adapted to the needs of country schools and I believe will be found a desirable text-book."

From Prof. M. A. O'Rear, Superintendent, Boonville, Mo., Public Schools.

"I have been much interested in 'Ravenel's Road Primer' and have given it a careful reading. It treats of a subject which is of

vital importance to all the people of our country and the information it contains should be known by every intelligent citizen.

"It is written in a style that brings it easily within the range of the mental ability of Grammar School boys and girls.

"I feel that this primer should have a place in every school where the problem of good roads is yet unsolved and this means practically every school in our land."

From E. T. Hale, Highway Engineer, Cooper County, Mo.

"I have examined the manuscript for 'Ravenel's Road Primer for School Children,' prepared for the Good Roads Department, National Congress of Mothers, by Capt. S. W. Ravenel, and find it up-to-date and fulfilling the requirements along the line for primary work."

From Hon. W. G. Pendleton, Mayor of Boonville, Mo., and Commissioner Boonville Special Road District.

"I am not a school man and therefore do not feel qualified to express an opinion on the desirability and practicability of teaching in the country schools the Elementary Principles and Practices of Road-making. But, as mayor of the City of Boonville for the last nine years and member for two years past of Boonville Special Road District, and therefore having been brought into close and practical touch with the subject of building and improving the streets of my city and roads of my district, I do most heartily express the opinion that if such a text book is adapted to such school course, 'Ravenel's Road Primer for School Children' presents the subject in the most concise and attractive form, scientifically treated and as comprehensively stated as the necessary simplicity for youthful understanding will permit.

"I take the greater pleasure in giving my endorsement to this work because of my long and intimate acquaintance with Mr. Ravenel, both personally and as a civil engineer employed by my

city and Special Road District, and because of the very high esteem in which I hold him professionally as well as personally."

From *Central Missouri Republican,* Senator J. M. Grimes, Editor, Boonville, Mo.

"Capt. Samuel W. Ravenel of this city has compiled and prepared at the request of the national chairman of the Good Roads for Child Welfare Department of the National Congress of Mothers, a Road Primer for school children. The manuscript has been submitted to such school men as Col. T. A. Johnston, Superintendent of Kemper, and Prof. M. A. O'Rear, Superintendent of the Boonville public schools, both of whom give the scope of the work their unqualified endorsement. This alone is sufficient to show that it is a work of merit. Capt. Ravenel is certainly to be congratulated on having prepared a work that is badly needed in the schools of this country."

From Charles E. Hirlinger, Book-seller for twenty-six years, Boonville, Mo.

"In my twenty-six years' experience in the retail book and stationery business I have been closely associated with the teachers of Cooper and Howard counties and feel that I know something of their needs.

"I believe that the 'Ravenel Road Primer' would be heartily received in our schools as an adopted text. I would like to see this recommended by the State Text-Book Commission for use in the schools of Missouri."

From Dr. William Mittelbach, for over twenty years Member and Secretary Board of Education, Boonville, Mo.

"I am very much pleased to endorse fully the text-book on road building as compiled by Capt. S. W. Ravenel.

"Such a text-book in our public schools will be of much benefit to our children, especially those living in the rural districts, and who will have to face this great problem of good roads.

"In this age of quick transportation, good roads will become more and more a live subject and a necessity. The boys and girls that live on the farm will be the better equipped to grapple with this problem, if some of the rudimentary principles of road-building are instilled in their young minds while at school. It is another step towards manual training for our boys, and opens another avenue where they can put into practice things learned at school."

From Prof. T. R. Kemp, Superintendent of Public Schools, Cooper County, Mo.

"I have gone over the manuscript of your work, 'Ravenel's Road Primer for School Children,' and I believe it certainly meets a long-felt need on this subject.

"It will be unquestionably one of the best publications for the purpose ever printed, and should be taught as a text-book in every public school in the State of Missouri.

"As a member of the Text-Book Commission of Cooper County, I most cheerfully recommend this Primer to our schools."

From Prof. John R. Kirk, President, First District Normal School, Kirksville, Missouri. Author of "The Idea of the Modern Rural School."

"I am profoundly impressed with the importance of the Road Primer for children, which is in preparation. If it proves half as good as it promises to be, it will be of incalculable value. No matter how good it proves to be, it will be followed by others and yet others.

"I am provoked beyond my power of expression that we have to use four horses on one wagon in order to haul twenty children

down hill to our Modern Rural School. We must have better roads. No roads, no schools; no modern roads, no modern schools; no modern schools, no keeping up with the procession.

"This school enters order for a few dozen of the first copies of the new Road Primer printed."

From Paul D. Sargent, Acting Director, Office of Public Roads, United States Department of Agriculture, Washington, D. C.

"I take pleasure in acknowledging receipt of the prospectus of your Road Primer.

"Our mileage of earth roads in the United States is so extensive that if it were laid out in one straight road, it would be sufficient to meet around the earth at the equator eighty times. Thus it will be seen that we have barely begun to improve our roads, and there is no better place to start the campaign of education than in our public schools. Your book should, therefore, be of great benefit, provided you can bring about its use in the public schools."

From the American Highway League, by resolutions unanimously passed.

"*Whereas,* it is a part of the avowed purpose of the National Congress of Mothers,—

"To raise the standard of Home and School life,— to interest men and women to coöperate in the work for truer, purer homes everywhere, because to accomplish the best results men and women must work together,— to surround the childhood of the nation with that wise, loving care in the impressionable years of life that will develop good citizens instead of law-breakers and criminals,— to carry the mother-love and mother-thought into all that concerns childhood,— in the home, school, church, state, and nation,— and

"*Whereas,* the purpose of the Country Life Department of the

National Congress of Mothers is to work for the betterment of Rural American Childhood, and

"Whereas, the most important first duty of this Committee is to stimulate interest in and promote Highway Improvement for child welfare in every part of the United States, and

"Whereas, Improved Highways is the basic economic problem of Rural child betterment, and,

"Whereas, the country community must be 'reconstructed because it has decayed in its church and retrograded in its schools,' and

"Whereas, the construction of roads necessarily precedes the construction of higher character of Rural Citizenship, and

"Whereas, the Highway Engineer is indirectly the most important agent and factor in the conservation of the material, educational, social, and æsthetic welfare of the child of the Agricultural Districts, and

"Whereas, Motherhood is anxious to coöperate with all agencies for the betterment of Childhood, and

"Whereas, a closer coöperation between the Highway Engineers of America and American Motherhood will influence Public Opinion in favor of building roads for a better citizenship by expert Highway Engineers, and

"Whereas, it is conceded by all physicians to be necessary to train the child, the future citizen, in the elementary knowledge of the sciences of hygiene and anatomy in order that he may be impressed with the importance of preserving his health, so, also, it becomes equally as important for the Highway Engineers to endorse the teaching of the elementary principles of road-building for the preservation not only of physical health, but also for the development of the commercial, educational, social, and hygienic conditions of the community surrounding him. Therefore,

"Be It Resolved; First: that the Association of Engineers forming the American Highway League, recommend to the Highway Department of their several States the appointment of a capable woman as special agent of the office of Highway Engineer, who shall lecture throughout the state, under the direction of the High-

way Engineer, with stereopticon and road pictures, so as to mould public opinion in favor of taxation for permanent road construction for the General Welfare; but particularly to create an intelligent sentiment in favor of teaching the children the value of Good Permanent Roads, built only by skilled Highway Engineers.

"Second; Be It Resolved, that the League of State Highway Engineers do endorse the teaching of the elementary principles of road administration and construction in the public schools so as to impress the school boy and girl with the importance of good roads and the value of an advanced system of maintenance."